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Scientific, Technical and Economic Committee for Fisheries (STECF) - Monitoring the performance of the Common Fisheries Policy (STECF-Adhoc-20-01)

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Abstract

Commission Decision of 25 February 2016 setting up a Scientific, Technical and Economic Committee for Fisheries, C(2016) 1084, OJ C 74, 26.2.2016, p. 4–10. The Commission may consult the group on any matter relating to marine and fisheries biology, fishing gear technology, fisheries economics, fisheries governance, ecosystem effects of fisheries, aquaculture or similar disciplines. This report deals with monitoring the performance of the Common Fisheries Policy.

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SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (STECF) - Monitoring the performance of the Common Fisheries Policy (STECF-Adhoc-20-01)

Background provided by the Commission

Article 50 of the Common Fisheries Policy (CFP; Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013) stipulates: "The Commission shall report annually to the European Parliament and to the Council on the progress on achieving maximum sustainable yield and on the situation of fish stocks, as early as possible following the adoption of the yearly Council Regulation fixing the fishing opportunities available in Union waters and, in certain non-Union waters, to Union vessels."

STECF observations

STECF has not reviewed and commented this ad-hoc study in plenary. However, the Chair of the STECF acknowledges receipt of it and confirms that the report is structured and elaborated in the same way as in 2019 (STECF, 2019a).

Nonetheless, STECF has updated the summary figures described and explained in the 2019 report, providing an overview of what is currently known regarding the achievement of the MSY objectives, drawing together the results from the different sea areas to provide a comparative picture. "Northeast Atlantic" refers to all stocks inside EU waters in the FAO Area 27, and "Mediterranean & Black Seas" refers to all stocks inside EU waters in the FAO Area 37. The comments and explanations detailed in the 2019 report still stand.

Stock status in the NE Atlantic

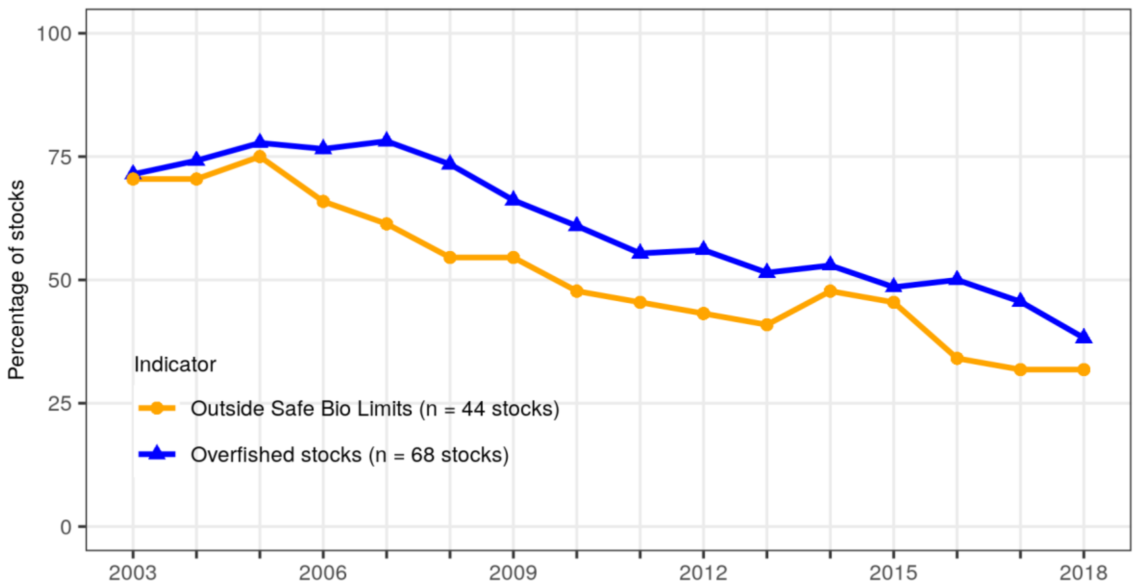

Figure 1. Trends in stock status in the Northeast Atlantic 2003-2018. Two indicators are presented: blue line: the proportion of overexploited stocks ($F>F_{MSY}$) within the sampling frame (62 to 68 stocks fully assessed, depending on year) and orange line: the proportion of stocks outside safe biological limits ($F>F_{pa}$ or $B<B_{pa}$) (out of a total of 44 stocks).

Table 1 Number of stocks overfished ($F>F_{MSY}$), or not overfished ($F \leq F_{MSY}$), and inside ($F \leq F_{pa}$ and $B \geq B_{pa}$) and outside ($F>F_{pa}$ or $B<B_{pa}$) safe biological limits (SBL) in 2018 in the NE Atlantic.

	Below F_{MSY}	**Above F_{MSY}**
Inside SBL	20	11
Outside SBL	2	12
Unknown	20	3

Trends in the fishing pressure (Ratio of F/F_{MSY})

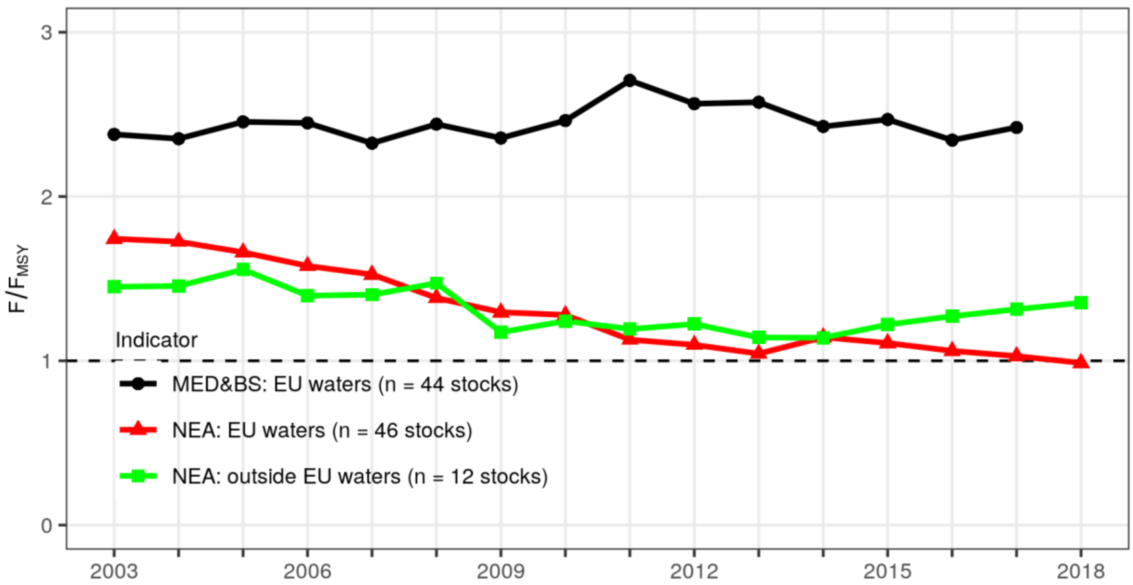

Figure 2. Trends in fishing pressure 2003-2018. Three model based indicators F/FMSY are presented (all referring to the median value of the model): one for 46 EU stocks with appropriate information in the NE Atlantic (red line); one for an additional set of 12 stocks also located in the NE Atlantic but outside EU waters (green line), and one for the 44 assessed stocks from the Mediterranean & Black Seas (black line).

Trends in Biomass

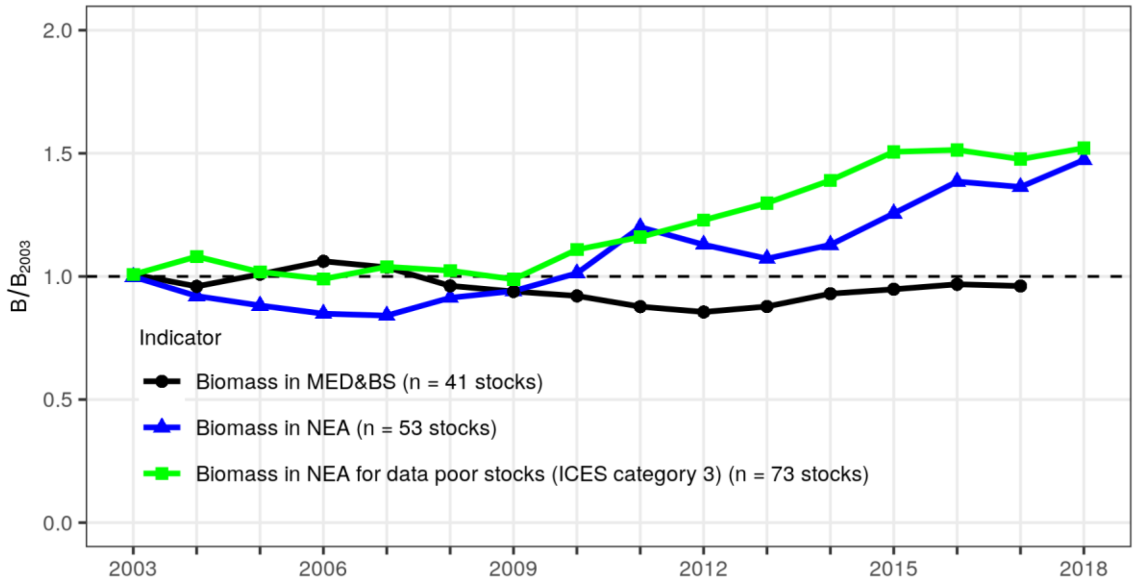

Figure 3. Trends in the indicators of stock biomass (median values of the model-based estimates relative to 2003). Three indicators are presented: one for the NE Atlantic (53 stocks considered, blue line); one for the Mediterranean & Black Seas (41 stocks, black line); and one for data limited stocks (ICES category 3, 73 stocks, green line).

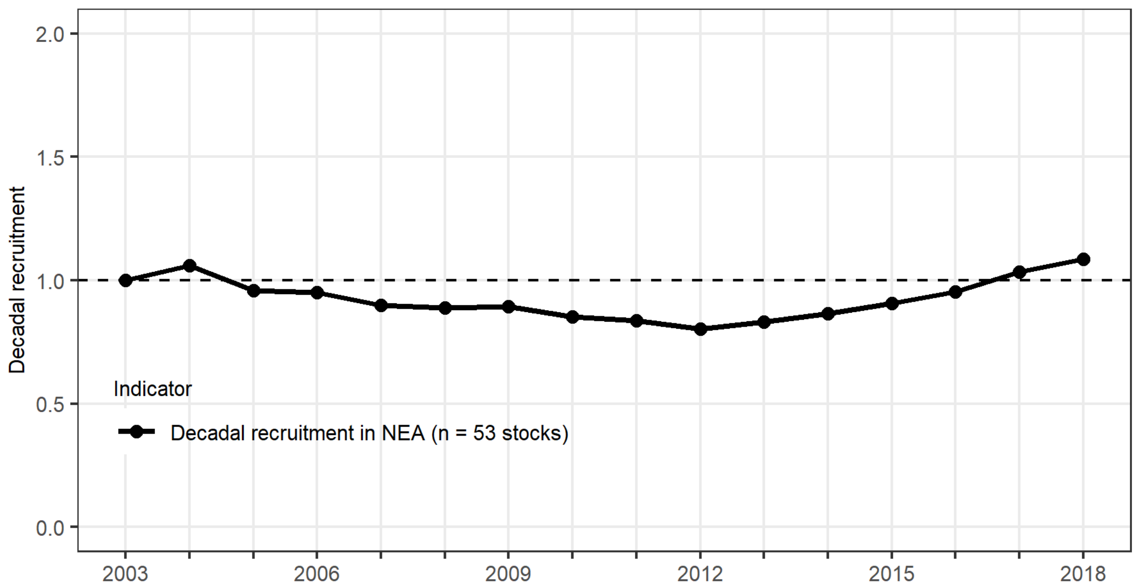

Figure 4. Trend in decadal recruitment scaled to 2003 in the Northeast Atlantic area (based on 53 stocks).

Coverage of biological stocks by the CFP monitoring

Table 2. Numbers of stocks assessed by ICES for different stock categories in different areas. Note that not all of these stocks are managed by TACs, and as such, numbers are higher than those used in the CFP monitoring analysis.

	ICES Stock Category						Total
	1	2	3	4	5	6	
Arctic Ocean	13	0	9	0	3	8	33
Azores	0	0	2	0	1	1	4
Baltic Sea	8	0	9	1	0	0	18
BoBiscay & Iberia	13	0	20	0	8	4	45
Celtic Seas	25	0	21	1	13	11	71
Faroes	3	0	1	0	0	0	4
Greater North Sea	23	0	15	5	5	2	50
Greenland Sea	5	0	3	0	0	1	9
Iceland Sea	1	0	0	0	1	0	2
NE Atlantic widely distributed stocks	7	1	7	0	1	0	16
Total	98	1	87	7	32	27	252

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REPORT TO THE STECF

Report of the ad hoc Expert Group on monitoring the performance of the Common Fisheries Policy

Ispra, Italy, January-March 2020

This report does not necessarily reflect the view of the STECF and the European Commission and in no way anticipates the Commission's future policy in this area

1 INTRODUCTION

Article 50 of the EU Common Fisheries Policy (REGULATION (EU) No 1380/2013) states:

"The Commission shall report annually to the European Parliament and to the Council on the progress on achieving maximum sustainable yield and on the situation of fish stocks, as early as possible following the adoption of the yearly Council Regulation fixing the fishing opportunities available in Union waters and, in certain non-Union waters, to Union vessels."

To fulfil its obligations to report to the European Parliament and the Council, each year, the European Commission requests the Scientific, Technical and Economic Committee for Fisheries (STECF) to compute a series of performance indicators and advise on the progress towards the provisions of Article 50.

In an attempt to make the process of computing each of the indicators consistent and transparent and to take account of issues identified and documented in previous CFP monitoring reports, a revised protocol was adopted by the STECF in 2019 (Annex I).

An ad hoc Expert Group comprising Experts from the European Commission's Joint Research Centre (JRC) was convened from January to March 2020 to compute the performance indicator values according to the agreed protocol (Annex I) and to report to the STECF plenary meeting scheduled for 16-20 March 2020.

1.1 Terms of Reference to the ad hoc Expert group

The Expert Group is requested to report on progress in achieving MSY objectives in line with CFP.

2 DATA AND METHODS

2.1 Data sources

The data sources used referred to the coastal waters of the EU in FAO areas 27 (Northeast Atlantic and adjacent Seas) and 37 (Mediterranean and Black Seas). The Mediterranean included GSAs 1, 5, 6, 7, 8, 9, 10, 11, 15, 16, 17, 18, 19, 25 and 29. The NE Atlantic included the ICES subareas "III", "IV" (excluding Norwegian waters of division IVa), "VI", "VII", "VIII", "IX" and "X".

2.1.1 Stock assessment information

For the NE Atlantic (FAO area 27), the information was downloaded from the ICES website (http://standardgraphs.ices.dk) on the 23rd January 2020, comprising the most recent published assessments, carried out up to and including 2019. A thorough process of data quality checks and corrections was performed to ensure the information downloaded was in agreement with the summary sheets published online (online annex I, https://stecf.jrc.ec.europa.eu/reports/cfp-monitoring).

For the Mediterranean region (FAO area 37), the information were extracted from the STECF Mediterranean Expert Working Group repositories (https://stecf.jrc.ec.europa.eu/reports/medbs) comprising the most recent published assessments carried out up to 2019 and from the GFCM stock assessment forms (http://www.fao.org/gfcm/data/safs/en) comprising the most recent published assessments carried out up to 2018.

The table reporting the URLs for the report or advice summary sheet for each stock is available at (online annex II, https://stecf.jrc.ec.europa.eu/reports/cfp-monitoring).

2.1.2 Management units information

For the NE Atlantic, management units are defined by TACs, annual fishing opportunities for a species or group of species in a Fishing Management Zone (FMZ). The information regarding TACs in 2016 was downloaded from the FIDES reporting system. Subsequently, this information was cleaned and processed, to identify the FMZ of relevance to this work, as well as the ICES rectangles they span to (Gibin, 2017; Scott et. al, 2017a; Scott et.al 2017b). This work was done once in 2017 and not updated since as there were no changes over time.

2.2 Methods

The methods applied and the definition of the sampling frames followed the protocol (Jardim et.al, 2015) agreed by STECF (2016) and updated following the discussion in STECF (2018). The updated protocol is presented in Annex I and the R code used to carry out the analysis in Annex II.

2.3 Points to note

- Stocks assessed with biomass dynamics models do not provide a value for F_{PA}, although they may provide a B_{PA} proxy (0.5 B_{MSY}). Consequently, such stocks cannot be used to compute safe biological limits (SBL; sections 3.2.3, 3.2.4).
- The Generalized Linear Mixed Model (GLMM) uses a shortened time series, starting in 2003, instead of the full time-series of available data. This has the advantage of balancing

the dataset by removing those years with only a low number of assessment estimates. It has the disadvantage of excluding data that could improve model fit.

- Indicators of trends computed with the GLMM show the average progress of the process they represent, including its uncertainty in terms of 50% and 95% confidence intervals. In the former case corresponding to the range between the 25% and 75% percentiles, and for the latter between the 2.5% and 97.5% percentiles.
- The GLMM fit within the bootstrap procedure does not converge for all resamples. Worst case is the biomass trends model fit with approximately 20% of non-convergence. Failed resamples were excluded when computating model-based indicators.
- The biomass indicator for stocks assessed with data limited methods (ICES stocks category 3) include also abundance indices, not only biomass indices. This is not fully clear in the protocol.

2.4 Differences from the 2019 CFP monitoring report

The methods used for this report were the same used for the 2019's report (STECF, 2019a).

3 NORTHEAST ATLANTIC AND ADJACENT SEAS (FAO REGION 27)

3.1 Number of stock assessments available to compute CFP performance indicators

The number of stock assessments with estimates of F/F_{MSY} for the years 2003-2018 for FAO Region 27 are given in Figure 5 and by ecoregion in Table 3.

The time-series of data available for each year and stock (data categories 1 and 2) is shown in Figure 6. For stocks without estimates in 2018 the estimates of F and SSB were assumed to be the same as 2017. Consequently, the number of stocks included to compute the indicator values for 2018 was 68.

The stocks used to compute each indicator are shown in Table 4, including data category 3 (73 stocks).

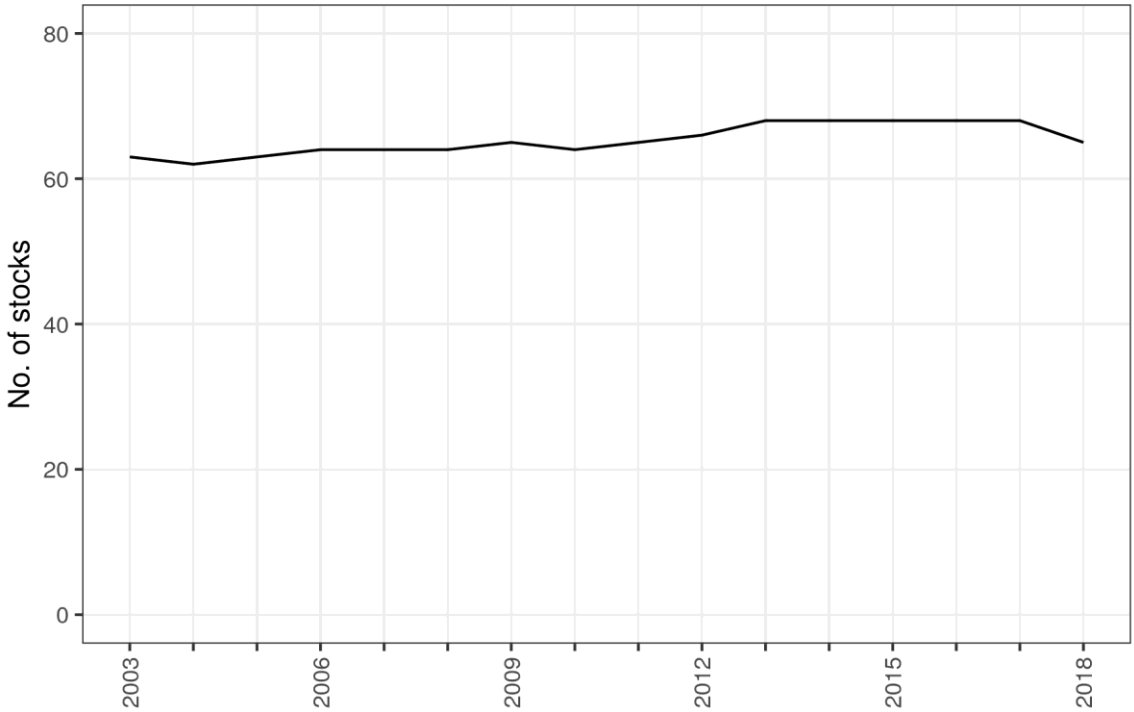
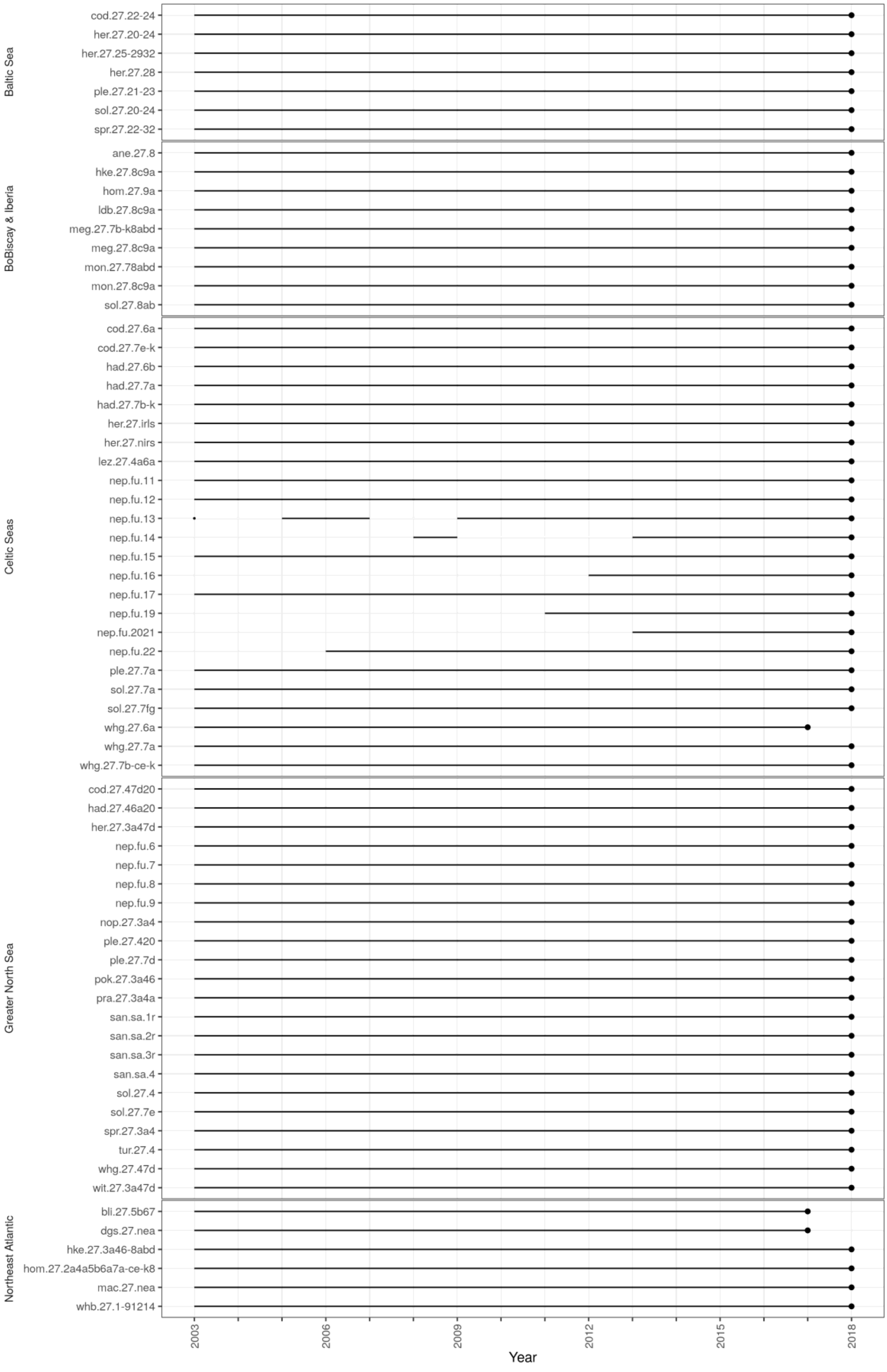


Figure 5. Number of stocks in the NE Atlantic for which estimates of F/F_{MSY} are available by year.

Table 3. Number of stocks in the ICES area for which estimates of F/F_{MSY} are available by ecoregion and year

EcoRegion	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
ALL	63	62	63	64	64	64	65	64	65	66	68	68	68	68	68	65
Baltic Sea	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
BoBiscay & Iberia	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Celtic Seas	19	18	19	20	20	20	21	20	21	22	24	24	24	24	24	23
Greater North Sea	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
Northeast Atlantic	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	4



Baltic Sea
cod.27.22-24
her.27.20-24
her.27.25-2932
her.27.28
ple.27.21-23
sol.27.20-24
spr.27.22-32
BoBiscay & Iberia
ane.27.8
hke.27.8c9a
hom.27.9a
ldb.27.8c9a
meg.27.7b-k8abd
meg.27.8c9a
mon.27.78abd
mon.27.8c9a
sol.27.8ab
Celtic Seas
cod.27.6a
cod.27.7e-k
had.27.6b
had.27.7a
had.27.7b-k
her.27.irls
her.27.nirs
lez.27.4a6a
nep.fu.11
nep.fu.12
nep.fu.13
nep.fu.14
nep.fu.15
nep.fu.16
nep.fu.17
nep.fu.19
nep.fu.2021
nep.fu.22
ple.27.7a
sol.27.7a
sol.27.7fg
whg.27.6a
whg.27.7a
whg.27.7b-ce-k
Greater North Sea
cod.27.47d20
had.27.46a20
her.27.3a47d
nep.fu.6
nep.fu.7
nep.fu.8
nep.fu.9
nop.27.3a4
ple.27.420
ple.27.7d
pok.27.3a46
pra.27.3a4a
san.sa.1r
san.sa.2r
san.sa.3r
san.sa.4
sol.27.4
sol.27.7e
spr.27.3a4
tur.27.4
whg.27.47d
wit.27.3a47d
Northeast Atlantic
bli.27.5b67
dgs.27.nea
hke.27.3a46-8abd
hom.27.2a4a5b6a7a-ce-k8
mac.27.nea
whb.27.1-91214
2003
2006
2009
2012
2015
2018
Year

Figure 6. Time series of stock assessment results in the NE Atlantic for which estimates of F/F_{MSY} are available by year. Blank records indicate no estimate available for stock and year.

Compared to last year's report, with relation to Category 1 & 2 stocks, two stocks have been added, four dropped and two were merged into a single stock.

The stocks added are:

- tur.27.4 and wit.27.3a47d. These stocks have been upgraded from Category 3 to Category 1.

The stocks dropped are:

- her.27.6a7bc, sol.27.7d, cod.27.7a and her.27.3031. These stocks have been downgraded from Category 1 to Category 3.

The stocks merged are:

- spr.27.4 and spr.27.3a were merged into spr.27.3a4.

cod.27.24-32 was not included in the analysis, despite having been upgraded from Category 3 to Category 1, due to the absence of reference points for F.

Four Category 1 stocks were not included in the analysis due to not having TACs: bss.27.4bc7ad-h, bss.27.8ab, her.27.1-24a514a and pil.27.8c9a.

As in last year's report (STECF, 2019a), the stock of nep.fu.3-4 has been dropped as having inconsistent abundance and harvest rate estimates across its time series, due to changes in the surveyed area.

For all stocks managed with a $B_{escapement}$ strategy, except Bay of Biscay anchovy (ane.27.8) and Norway pout in the North Sea, Skagerrak and Kattegat (nop.27.3a4), $MSYB_{escapement}$ was set by ICES at B_{PA} instead of B_{MSY}. Norway pout in the North Sea, Skagerrak and Kattegat (nop.27.3a4) uses a probabilistic method to set the catches: $C_{y+1}=C|(P[SSB<B_{lim}]=0.05)$. For this stock, the lower (0.025%) boundary of the SSB confidence interval was compared to B_{lim}. Bay of Biscay anchovy (ane.27.8) uses a HCR with Biomass triggers. ICES does not report reference points other than B_{lim}. The HCR's upper biomass trigger was used as $MSYB_{escapement}$.

There are 39 stocks for which MSYBtrigger was set at Bpa levels, of which 3 have explicitly estimated both reference points (hom.27.9a, pra.27.3a4a and sol.27.7e), all the others used ICES's default procedure. For the latter cases MSYBtrigger was set to unknown as discussed by STECF (2018b).

As in last year's report (STECF, 2019a) the stock of pan-barn was not included in the indicator F/F_{MSY} for stocks outside EU waters of FAO region 27, due to its large impact in the indicator values.

For the stock nep.fu.13 the status of the stock is derived comparing the combined Firth of Clyde and Sound of Jura harvest rate with the Firth of Clyde harvest rate MSY, in agreement with the ICES procedures.

To keep consistency with previous reports and ICES definitions, widely distributed stocks are referred to as "Northeast Atlantic" in the figures and tables of this section.

Table 4. Indicators computed for each stocks.

FishStock	Year	above/below Fmsy	in/out SBL	$F \sim F_{MSY}$ V $B \sim B_{MSY}$	F/Fmsy trends	Biomass trends	Decadal recruitment trends	Biomass data category 3 trends
ane.27.8	2018	X				X	X	
ane.27.9a	2018							X
anf.27.3a46	2018							X
ank.27.78abd	2018							X
ank.27.8c9a	2018							X
aru.27.5b6a	2018							X
aru.27.6b7-1012	2018							X
bli.27.5b67	2017	X	X		X	X	X	
bll.27.22-32	2016							X
bll.27.3a47de	2018							X
boc.27.6-8	2018							X
cod.27.21	2018							X
cod.27.22-24	2018	X	X		X	X	X	
cod.27.47d20	2018	X	X		X	X	X	
cod.27.6a	2018	X	X		X	X	X	
cod.27.7a	2018							X
cod.27.7e-k	2018	X	X		X	X	X	
dab.27.22-32	2016							X
dab.27.3a4	2018							X
dgs.27.nea	2017	X		X		X	X	
fle.27.2223	2018							X
fle.27.2425	2018							X
fle.27.2628	2016							X
fle.27.2729-32	2016							X
fle.27.3a4	2018							X
gfb.27.nea	2017							X
gug.27.3a47d	2018							X
had.27.46a20	2018	X	X		X	X	X	
had.27.6b	2018	X	X		X	X	X	
had.27.7a	2018	X	X	X	X	X	X	
had.27.7b-k	2018	X	X		X	X	X	
her.27.20-24	2018	X	X		X	X	X	
her.27.25-2932	2018	X	X		X	X	X	
her.27.28	2018	X	X	X	X	X	X	
her.27.3031	2018							X
her.27.3a47d	2018	X	X	X	X	X	X	
her.27.6a7bc	2018							X
her.27.irls	2018	X	X		X	X	X	
her.27.nirs	2018	X	X		X	X	X	

FishStock	Year	above/below Fmsy	in/out SBL	$F \sim F_{MSY}$ V $B \sim B_{MSY}$	F/Fmsy trends	Biomass trends	Decadal recruitment trends	Biomass data category 3 trends
hke.27.3a46-8abd	2018	X	X		X	X	X	
hke.27.8c9a	2018	X	X		X	X	X	
hom.27.2a4a5b6a7a-ce-k8	2018	X	X		X	X	X	
hom.27.3a4bc7d	2018							X
hom.27.9a	2018	X		X	X	X	X	
ldb.27.8c9a	2018	X	X		X	X	X	
lem.27.3a47d	2018							X
lez.27.4a6a	2018	X		X	X			
lez.27.6b	2018							X
lin.27.3a4a6-91214	2018							X
lin.27.5b	2018							X
mac.27.nea	2018	X	X		X	X	X	
meg.27.7b-k8abd	2018	X	X		X	X	X	
meg.27.8c9a	2018	X	X		X	X	X	
mon.27.78abd	2018	X	X		X	X	X	
mon.27.8c9a	2018	X	X	X	X	X	X	
mur.27.3a47d	2018							X
nep.fu.11	2018	X		X				
nep.fu.12	2018	X		X				
nep.fu.13	2018	X		X				
nep.fu.14	2018	X		X				
nep.fu.15	2018	X		X				
nep.fu.16	2018	X						
nep.fu.17	2018	X		X				
nep.fu.19	2018	X		X				
nep.fu.2021	2018	X						
nep.fu.22	2018	X		X				
nep.fu.25	2016							X
nep.fu.2627	2018							X
nep.fu.2829	2018							X
nep.fu.31	2016							X
nep.fu.6	2018	X		X				
nep.fu.7	2018	X		X				
nep.fu.8	2018	X		X				
nep.fu.9	2018	X		X				
nop.27.3a4	2018	X				X	X	
ple.27.21-23	2018	X	X		X	X	X	
ple.27.24-32	2018							X
ple.27.420	2018	X	X	X	X	X	X	
ple.27.7a	2018	X	X	X	X	X	X	
ple.27.7d	2018	X	X		X	X	X	

FishStock	Year	above/below Fmsy	in/out SBL	$F \sim F_{MSY}$ V $B \sim B_{MSY}$	F/Fmsy trends	Biomass trends	Decadal recruitment trends	Biomass data category 3 trends
ple.27.7e	2018							X
ple.27.7fg	2018							X
ple.27.7h-k	2018							X
pok.27.3a46	2018	X	X		X	X	X	
pra.27.3a4a	2018	X	X	X	X	X	X	
raj.27.1012	2018							X
reb.2127.dp	2018							X
rjc.27.3a47d	2018							X
rjc.27.6	2017							X
rjc.27.7afg	2017							X
rjc.27.8	2017							X
rjc.27.9a	2017							X
rje.27.7fg	2017							X
rjh.27.4c7d	2018							X
rjh.27.9a	2017							X
rjm.27.3a47d	2018							X
rjm.27.67bj	2017							X
rjm.27.7ae-h	2017							X
rjm.27.8	2017							X
rjm.27.9a	2017							X
rjn.27.3a4	2018							X
rjn.27.678abd	2017							X
rjn.27.8c	2017							X
rjn.27.9a	2017							X
rju.27.7de	2017							X
rng.27.3a	2017							X
san.sa.1r	2018	X				X	X	
san.sa.2r	2018	X				X	X	
san.sa.3r	2018	X				X	X	
san.sa.4	2018	X				X	X	
sbr.27.10	2018							X
sbr.27.9	2017							X
sdv.27.nea	2018							X
sho.27.67	2018							X
sho.27.89a	2018							X
sol.27.20-24	2018	X	X		X	X	X	
sol.27.4	2018	X	X		X	X	X	
sol.27.7a	2018	X	X		X	X	X	
sol.27.7d	2018							X
sol.27.7e	2018	X	X	X	X	X	X	
sol.27.7fg	2018	X	X		X	X	X	

FishStock	Year	above/below Fmsy	in/out SBL	$F \sim F_{MSY}$ V $B \sim B_{MSY}$	F/Fmsy trends	Biomass trends	Decadal recruitment trends	Biomass data category 3 trends
sol.27.7h-k	2018							X
sol.27.8ab	2018	X	X		X	X	X	
spr.27.22-32	2018	X	X		X	X	X	
spr.27.3a4	2018	X				X	X	
spr.27.7de	2018							X
syc.27.3a47d	2018							X
syc.27.67a-ce-j	2018							X
syc.27.8abd	2018							X
syc.27.8c9a	2018							X
syt.27.67	2018							X
tur.27.22-32	2017							X
tur.27.3a	2018							X
tur.27.4	2018	X	X	X	X	X	X	
usk.27.3a45b6a7-912b	2018							X
whb.27.1-91214	2018	X	X		X	X	X	
whg.27.47d	2018	X	X		X	X	X	
whg.27.6a	2017	X	X		X	X	X	
whg.27.7a	2018	X	X		X	X	X	
whg.27.7b-ce-k	2018	X	X		X	X	X	
wit.27.3a47d	2018	X	X		X	X	X	
Total		**68**	**44**	**24**	**46**	**53**	**53**	**73**

3.2 Indicators of management performance

The first set of indicators (Figure 7 to Figure 18 and Table 5 to Table 10) compute the number with relation to specific thresholds. The presentation of these indicators is made in pairs, with one indicator showing the number of stocks above/outside the relevant thresholds, followed by another showing the number of stocks below/inside. The second set of indicators (Figure 19 to Figure 26 and Table 11 to Table 18) depicts time trends of important variables. These indicators are computed using a statistical model. Most indicators have a global and a regional depiction.

3.2.1 *Number of stocks by year where fishing mortality exceeded F_{MSY}*

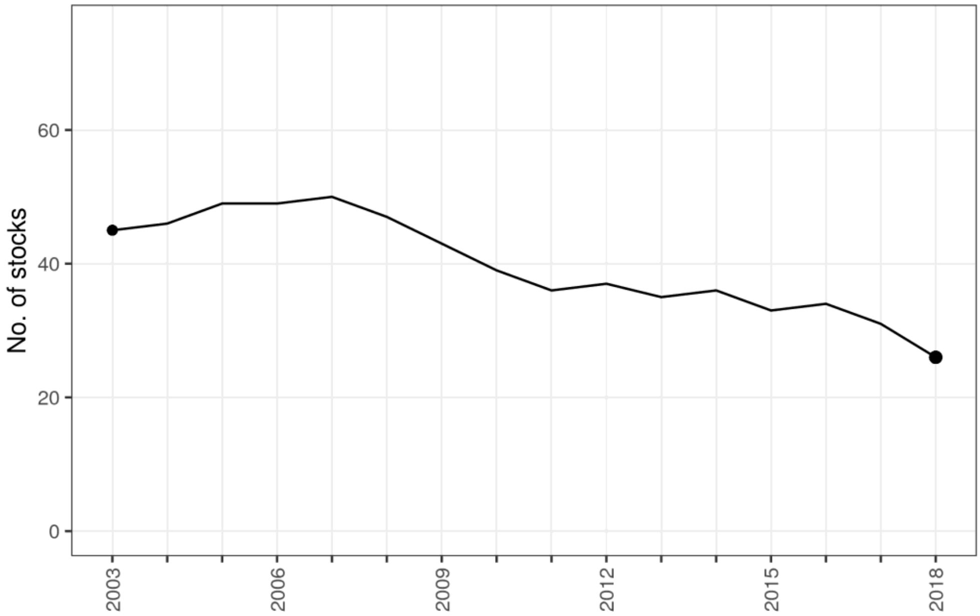


Figure 7. Number of stocks by year for which fishing mortality (F) exceeded F_{MSY}.

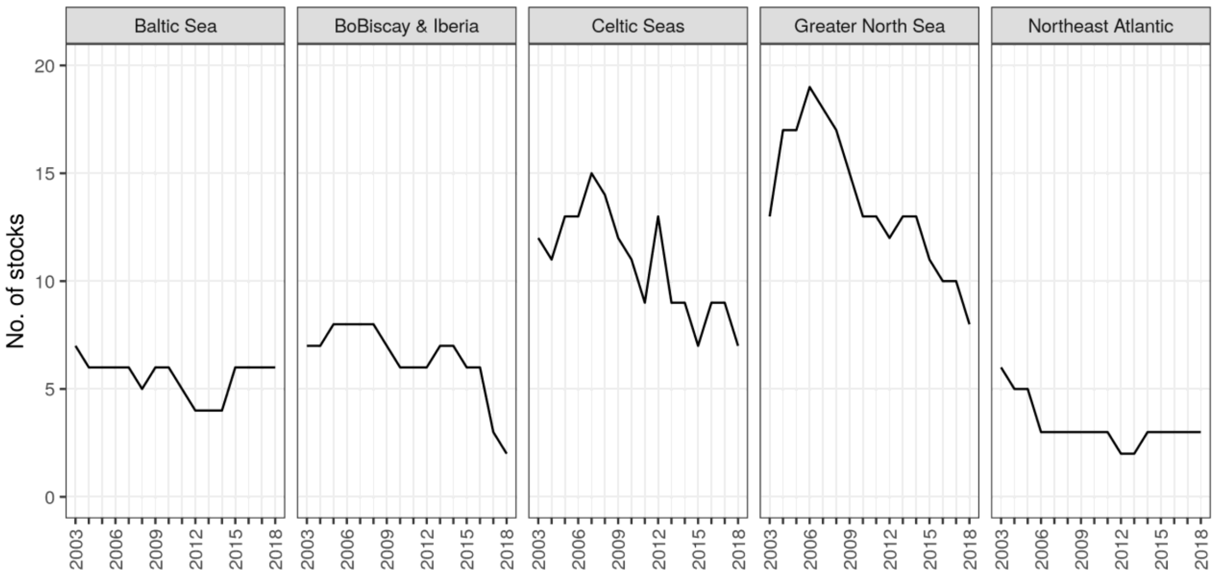


Figure 8. Number of stocks by ecoregion for which fishing mortality (F) exceeded F_{MSY}.

Table 5. Number of stocks by ecoregion for which fishing mortality (F) exceeded F_{MSY}.

EcoRegion	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
ALL	45	46	49	49	50	47	43	39	36	37	35	36	33	34	31	26
Baltic Sea	7	6	6	6	6	5	6	6	5	4	4	4	6	6	6	6
BoBiscay & Iberia	7	7	8	8	8	8	7	6	6	6	7	7	6	6	3	2
Celtic Seas	12	11	13	13	15	14	12	11	9	13	9	9	7	9	9	7
Greater North Sea	13	17	17	19	18	17	15	13	13	12	13	13	11	10	10	8
Northeast Atlantic	6	5	5	3	3	3	3	3	3	2	2	3	3	3	3	3

3.2.2 *Number of stocks by year where fishing mortality was equal to, or less than F_{MSY}*

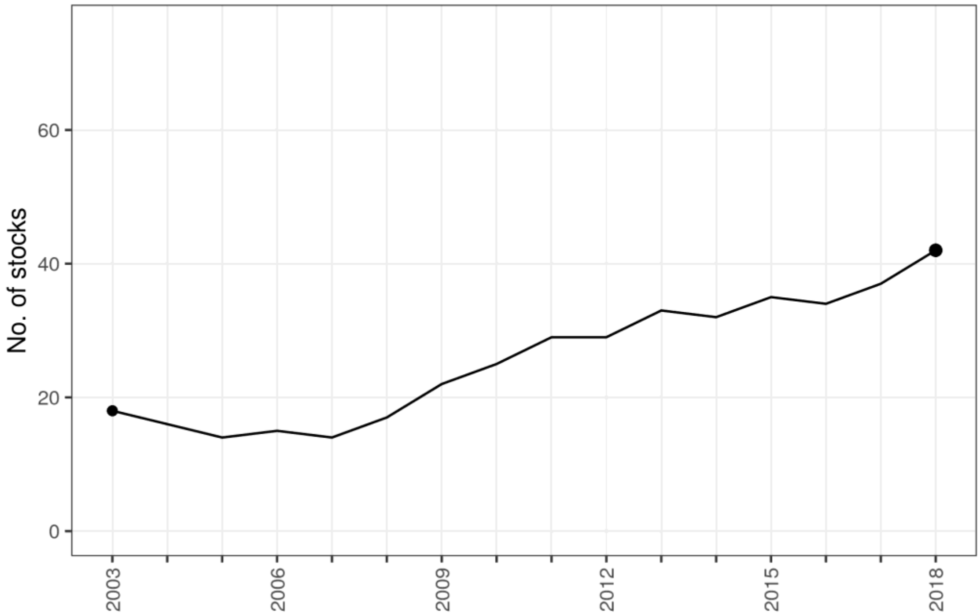


Figure 9. Number of stocks by year for which fishing mortality (F) did not exceed F_{MSY}.

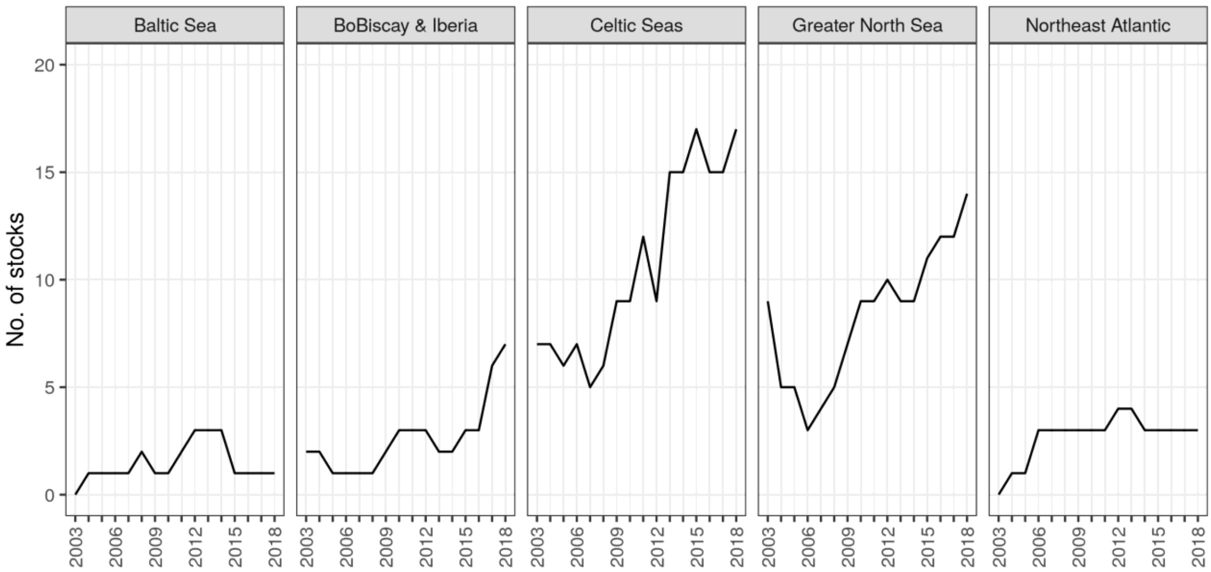


Figure 10. Number of stocks by ecoregion for which fishing mortality (F) did not exceed F_{MSY}.

Table 6. Number of stocks by ecoregion for which fishing mortality (F) did not exceed F_{MSY}.

EcoRegion	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
ALL	18	16	14	15	14	17	22	25	29	29	33	32	35	34	37	42
Baltic Sea	0	1	1	1	1	2	1	1	2	3	3	3	1	1	1	1
BoBiscay & Iberia	2	2	1	1	1	1	2	3	3	3	2	2	3	3	6	7
Celtic Seas	7	7	6	7	5	6	9	9	12	9	15	15	17	15	15	17
Greater North Sea	9	5	5	3	4	5	7	9	9	10	9	9	11	12	12	14
Northeast Atlantic	0	1	1	3	3	3	3	3	3	4	4	3	3	3	3	3

3.2.3 *Number of stocks outside safe biological limits*

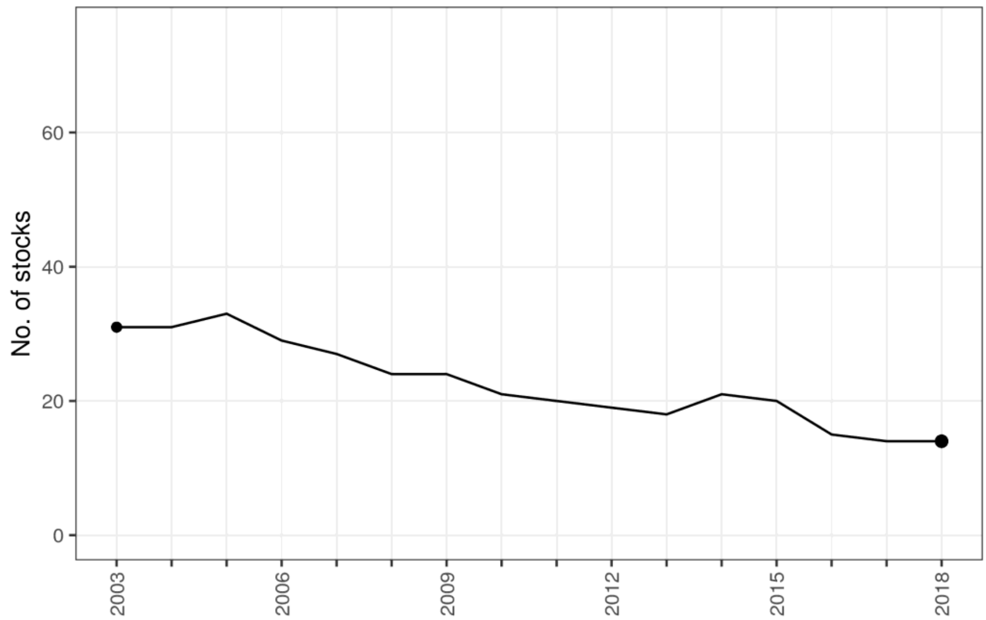


Figure 11. Number of stocks outside safe biological limits by year.

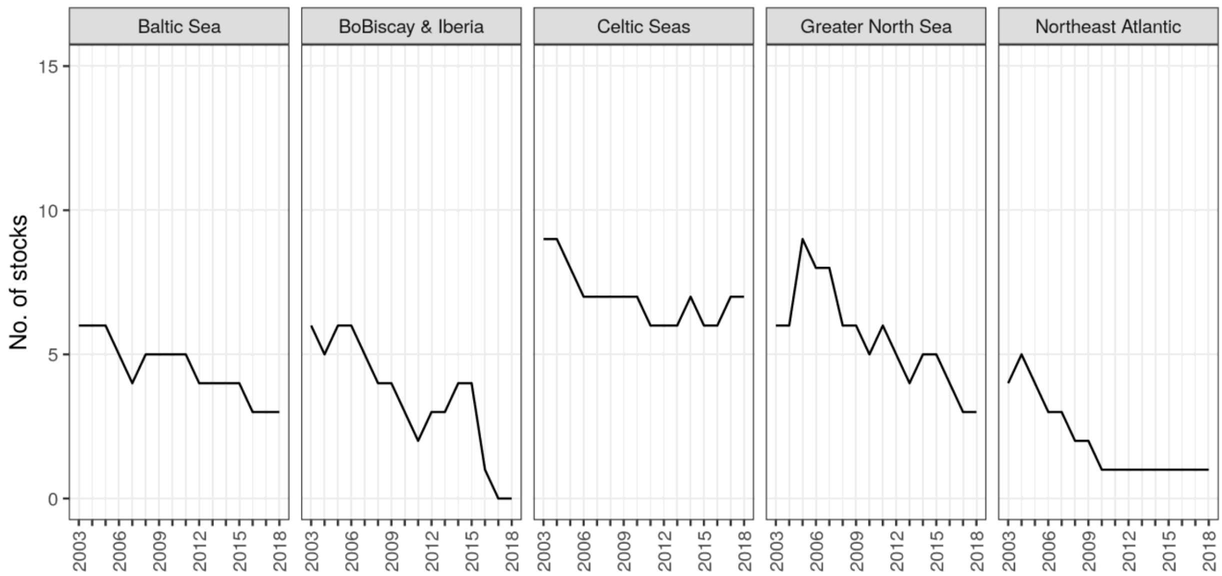


Figure 12. Number of stocks outside safe biological limits by ecoregion.

Table 7. Number of stocks outside safe biological limits by ecoregion.

EcoRegion	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
ALL	31	31	33	29	27	24	24	21	20	19	18	21	20	15	14	14
Baltic Sea	6	6	6	5	4	5	5	5	5	4	4	4	4	3	3	3
BoBiscay & Iberia	6	5	6	6	5	4	4	3	2	3	3	4	4	1	0	0
Celtic Seas	9	9	8	7	7	7	7	7	6	6	6	7	6	6	7	7
Greater North Sea	6	6	9	8	8	6	6	5	6	5	4	5	5	4	3	3
Northeast Atlantic	4	5	4	3	3	2	2	1	1	1	1	1	1	1	1	1

3.2.4 Number of stocks inside safe biological limits

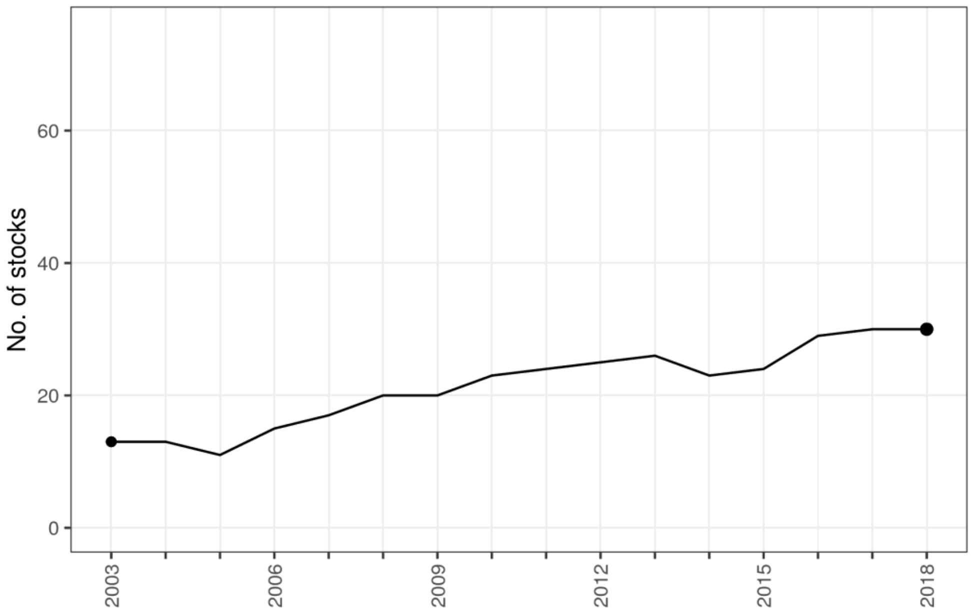


Figure 13. Number of stocks inside safe biological limits by year.

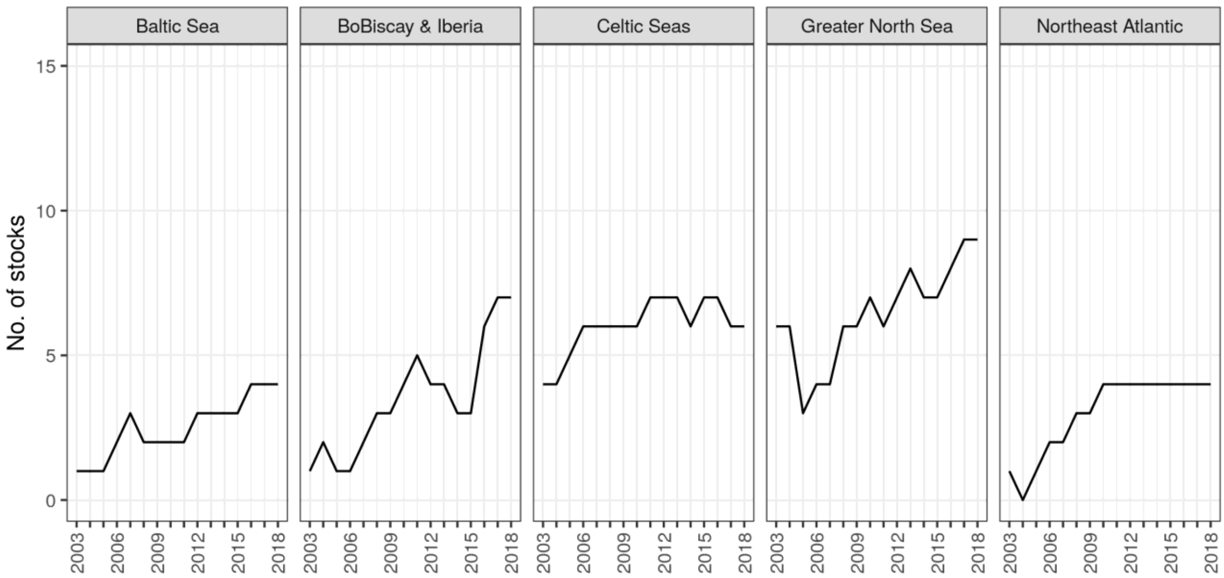


Figure 14. Number of stocks inside safe biological limits by ecoregion.

Table 8. Number of stocks inside safe biological limits by ecoregion.

EcoRegion	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
ALL	13	13	11	15	17	20	20	23	24	25	26	23	24	29	30	30
Baltic Sea	1	1	1	2	3	2	2	2	2	3	3	3	3	4	4	4
BoBiscay & Iberia	1	2	1	1	2	3	3	4	5	4	4	3	3	6	7	7
Celtic Seas	4	4	5	6	6	6	6	6	7	7	7	6	7	7	6	6
Greater North Sea	6	6	3	4	4	6	6	7	6	7	8	7	7	8	9	9
Northeast Atlantic	1	0	1	2	2	3	3	4	4	4	4	4	4	4	4	4

3.2.5 *Number of stocks with F above Fmsy or SSB below B_{MSY}*

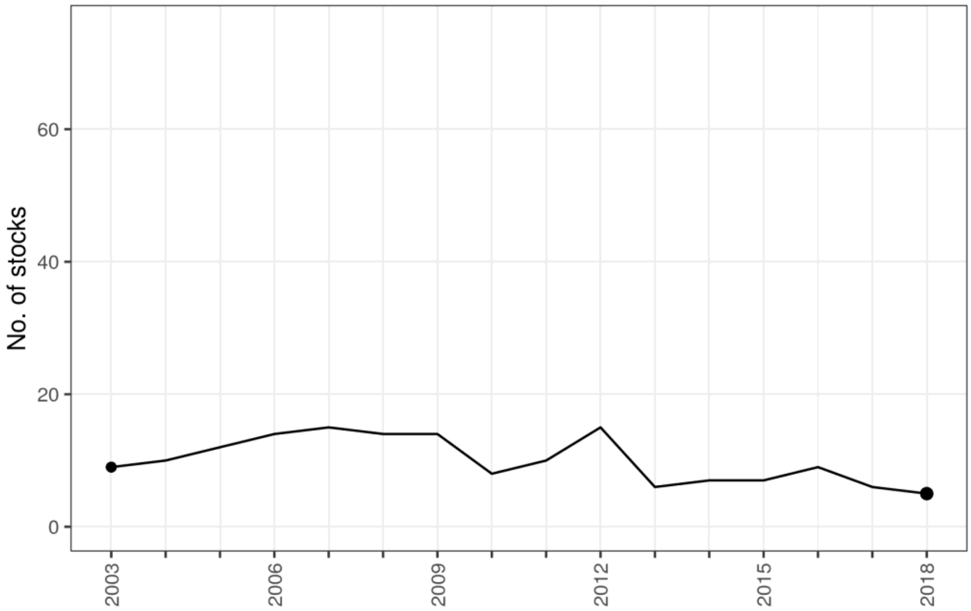


Figure 15. Number of stocks with F above Fmsy or SSB below B_{MSY} by year.

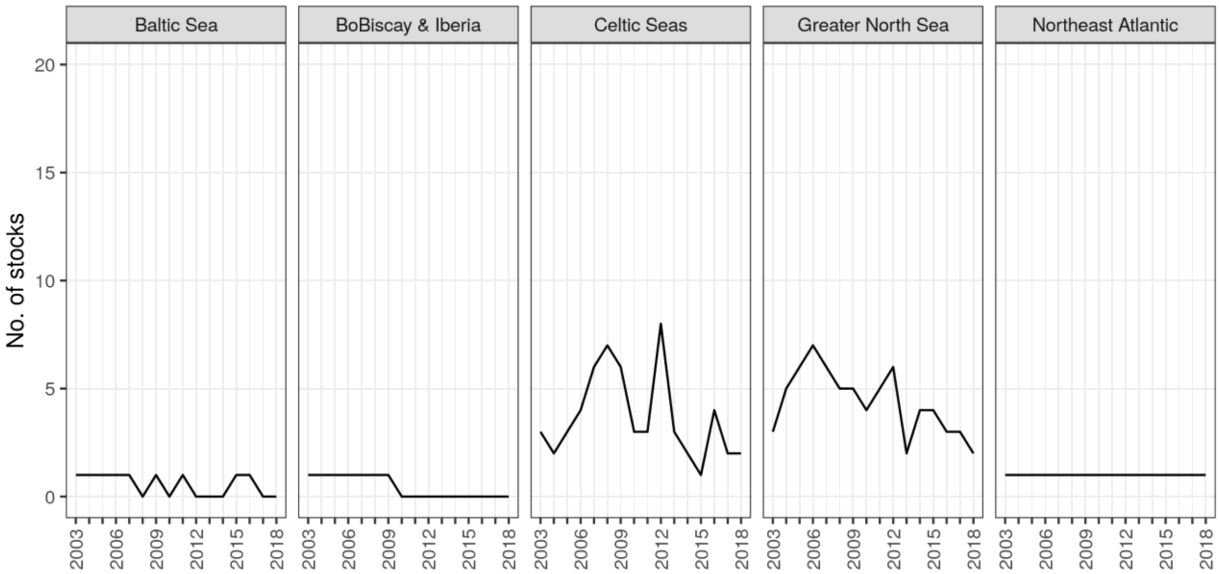


Figure 16. Number of stocks with F above F_{MSY} or SSB below B_{MSY} by ecoregion.

Table 9. Number of stocks with F above F_{MSY} or SSB below B_{MSY} by ecoregion.

EcoRegion	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
ALL	9	10	12	14	15	14	14	8	10	15	6	7	7	9	6	5
Baltic Sea	1	1	1	1	1	0	1	0	1	0	0	0	1	1	0	0
BoBiscay & Iberia	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
Celtic Seas	3	2	3	4	6	7	6	3	3	8	3	2	1	4	2	2
Greater North Sea	3	5	6	7	6	5	5	4	5	6	2	4	4	3	3	2
Northeast Atlantic	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

3.2.6 *Number of stocks with F below or equal to Fmsy and SSB above or equal to B_{MSY}*

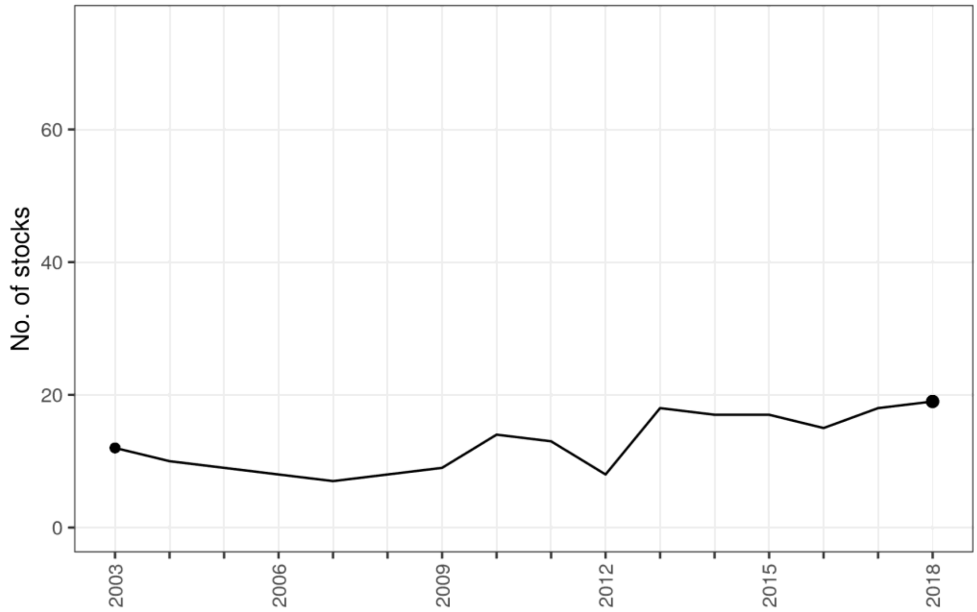


Figure 17. Number of stocks with F below or equal to F_{MSY} and SSB above or equal to B_{MSY}.

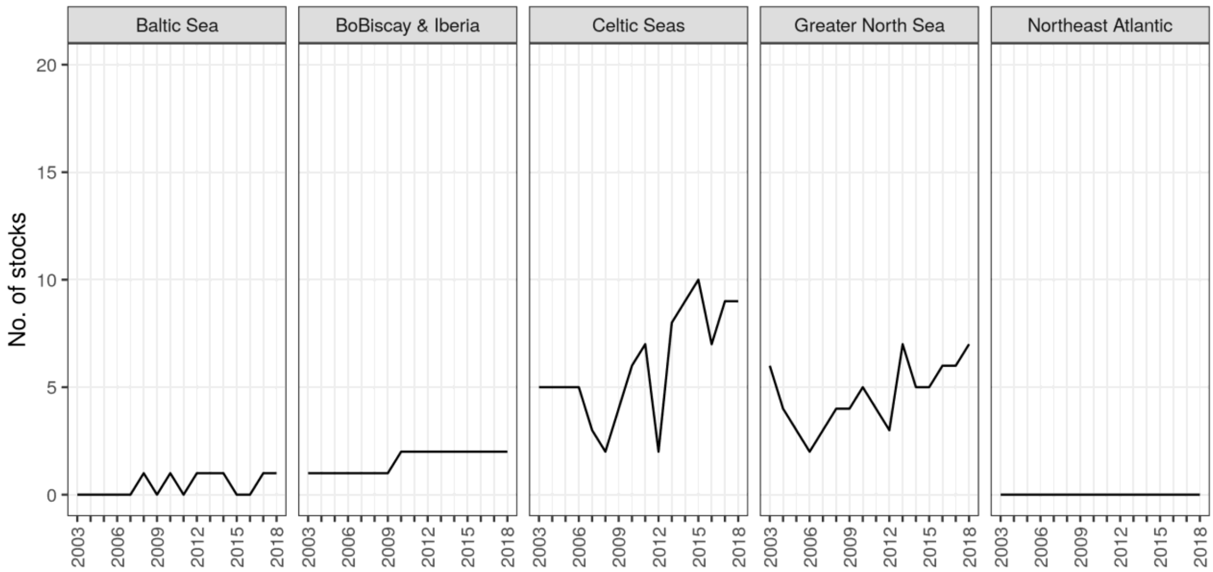


Figure 18. Number of stocks with F below or equal to F_{MSY} and SSB above or equal to B_{MSY} by ecoregion.

Table 10. Number of stocks with F below or equal to Fmsy and SSB above or equal to B_{MSY} by ecoregion.

EcoRegion	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
ALL	12	10	9	8	7	8	9	14	13	8	18	17	17	15	18	19
Baltic Sea	0	0	0	0	0	1	0	1	0	1	1	1	0	0	1	1
BoBiscay & Iberia	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2
Celtic Seas	5	5	5	5	3	2	4	6	7	2	8	9	10	7	9	9
Greater North Sea	6	4	3	2	3	4	4	5	4	3	7	5	5	6	6	7
Northeast Atlantic	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

3.2.7 Trend in F/F_{MSY}

The trend in F/F_{MSY} is given in Figure 19 and associated percentiles in Table 11. Figure 19 shows the indicator values since 2016 close to 1, which means that over all stocks, on average, the exploitation levels are close to F_{MSY}.

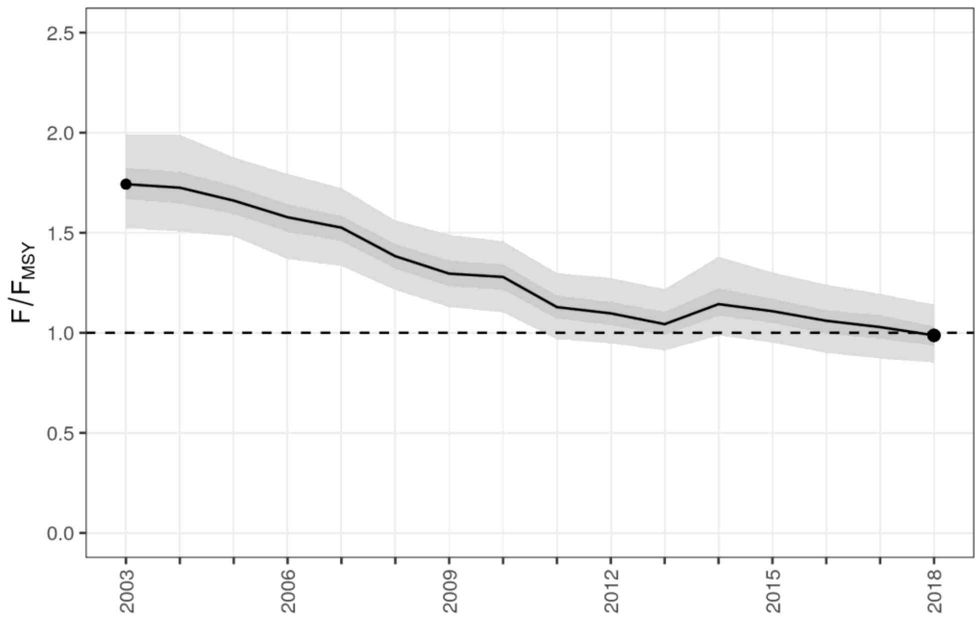


Figure 19. Trend in F/F_{MSY} (based on 46 stocks). Dark grey zone shows the 50% confidence interval; the light grey zone shows the 95% confidence interval.

Table 11. Percentiles for F/F_{MSY} by year.

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
2.5%	1.52	1.51	1.48	1.37	1.33	1.21	1.13	1.10	0.97	0.95	0.91	0.99	0.95	0.90	0.87	0.85
25%	1.67	1.65	1.60	1.51	1.46	1.32	1.23	1.22	1.07	1.04	0.99	1.09	1.05	1.00	0.97	0.94
50%	1.74	1.72	1.66	1.58	1.53	1.38	1.30	1.28	1.13	1.10	1.04	1.14	1.11	1.06	1.03	0.99
75%	1.82	1.80	1.73	1.64	1.58	1.44	1.36	1.34	1.18	1.15	1.10	1.22	1.17	1.11	1.09	1.03
97.5%	1.99	1.99	1.88	1.79	1.72	1.56	1.49	1.46	1.30	1.27	1.22	1.38	1.30	1.24	1.20	1.14

Trends in F/F_{MSY} by ecoregion are given in Figure 20 and Table 12. The regional analysis was carried out using the same model applied to regional datasets. Due to the small number of stocks in each ecoregion (ranging from 5 for the Northeast Atlantic to 14 for the Celtic Seas) it was not possible to compute confidence intervals.

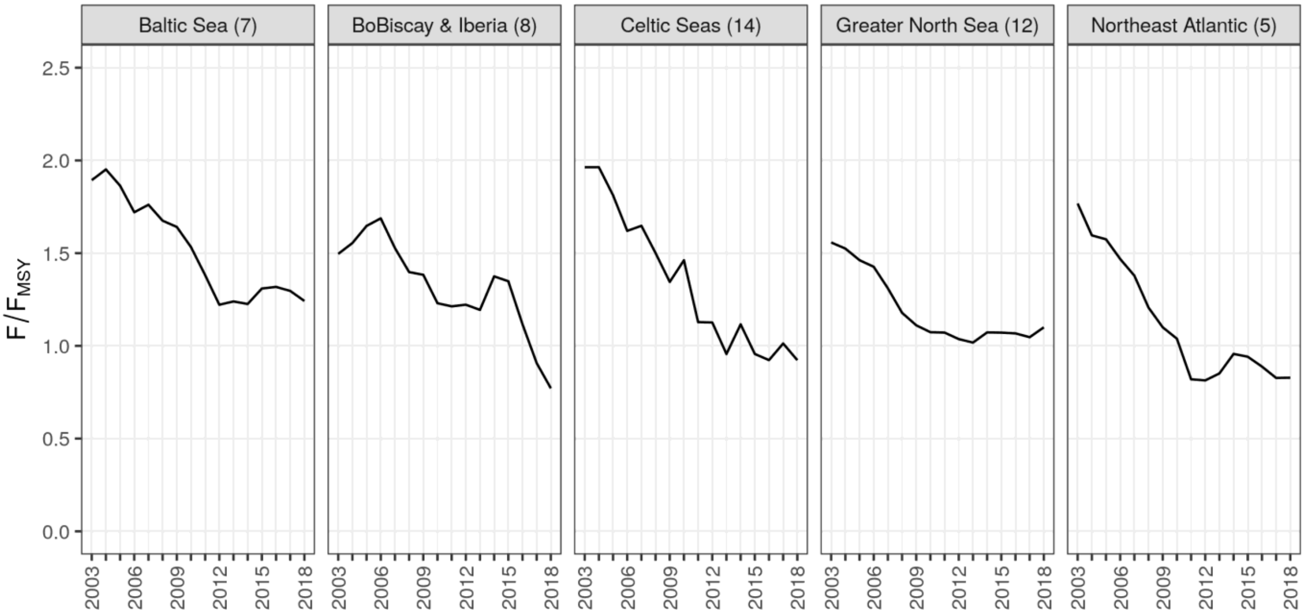


Figure 20. Trend in F/F_{MSY} by ecoregion. The number of stocks in each ecoregion are shown between parentheses.

Table 12. Trend in F/F_{MSY} by ecoregion.

EcoRegion	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Baltic Sea	1.89	1.95	1.86	1.72	1.76	1.67	1.64	1.53	1.38	1.22	1.24	1.23	1.31	1.32	1.30	1.24
BoBiscay & Iberia	1.50	1.55	1.65	1.69	1.53	1.40	1.38	1.23	1.21	1.22	1.19	1.37	1.35	1.12	0.91	0.77
Celtic Seas	1.96	1.96	1.81	1.62	1.65	1.50	1.34	1.46	1.13	1.13	0.96	1.12	0.96	0.92	1.01	0.92
Greater North Sea	1.56	1.52	1.46	1.43	1.31	1.18	1.11	1.07	1.07	1.04	1.02	1.07	1.07	1.07	1.05	1.10
Northeast Atlantic	1.77	1.60	1.57	1.47	1.38	1.21	1.10	1.04	0.82	0.81	0.85	0.96	0.94	0.89	0.83	0.83

3.2.8 Trend in F/F_{MSY} for stocks outside EU waters

For comparison purposes the same model used in section 3.2.7 was applied to stocks assessed by ICES which span over areas mostly outside EU waters in FAO region 27 (Figure 21 and Table 13). The reduced number of stocks available renders the indicator unstable and not very precise, hence the large confidence intervals.

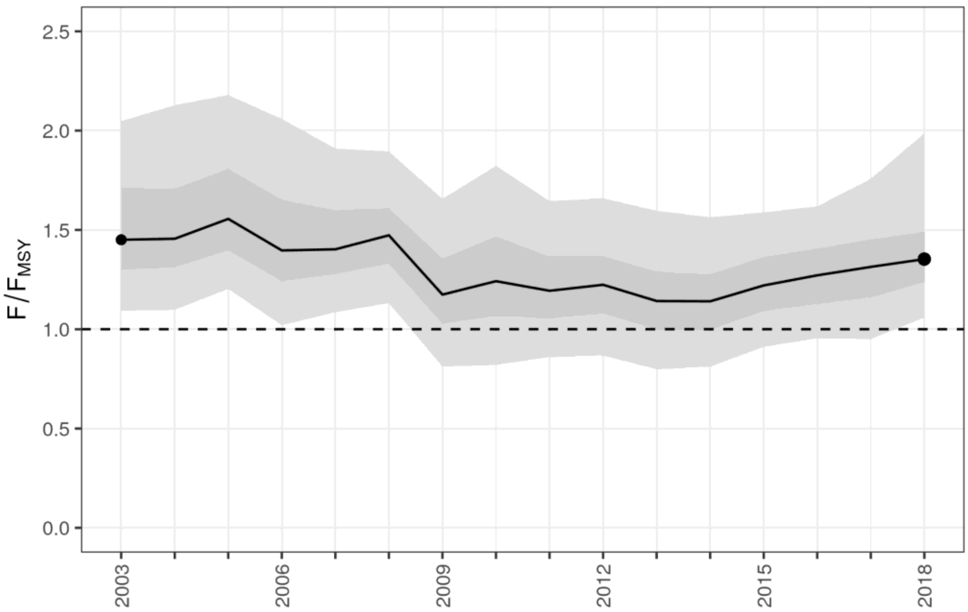


Figure 21. Trend in F/F_{MSY} for stocks outside EU waters (based on 12 stocks). Dark grey zone shows the 50% confidence interval; the light grey zone shows the 95% confidence interval.

Table 13. Percentiles for F/F_{MSY} for stocks outside EU waters.

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
2.5%	1.09	1.10	1.20	1.02	1.09	1.13	0.81	0.82	0.86	0.87	0.80	0.81	0.91	0.95	0.95	1.06
25%	1.30	1.31	1.40	1.24	1.28	1.33	1.03	1.07	1.06	1.08	1.00	1.00	1.09	1.13	1.16	1.24
50%	1.45	1.46	1.56	1.40	1.40	1.47	1.17	1.24	1.19	1.22	1.14	1.14	1.22	1.27	1.31	1.35
75%	1.71	1.71	1.81	1.65	1.60	1.61	1.35	1.47	1.36	1.37	1.29	1.28	1.36	1.40	1.45	1.49
97.5%	2.05	2.13	2.18	2.06	1.91	1.89	1.66	1.82	1.65	1.66	1.60	1.56	1.59	1.62	1.76	1.99

3.2.9 *Trend in SSB (relative to 2003)*

Figure 22 and Table 14 present the evolution of SSB over the period of the study, scaled to the initial (2003) value for presentation purposes. Over the time series SSB shows a generally increasing pattern, continuing the path estimated in previous years.

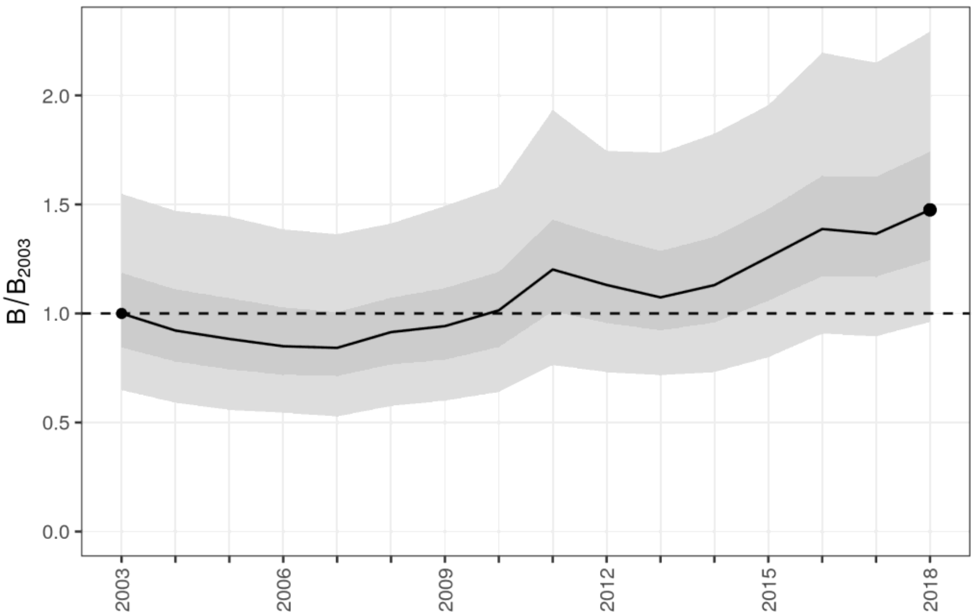


Figure 22. Trend in SSB relative to 2003 (based on 53 stocks). Dark grey zone shows the 50% confidence interval; the light grey zone shows the 95% confidence interval.

Table 14. Percentiles for SSB relative to 2003.

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
2.5%	0.65	0.59	0.56	0.54	0.53	0.58	0.60	0.64	0.76	0.73	0.72	0.73	0.80	0.91	0.90	0.96
25%	0.85	0.78	0.74	0.72	0.71	0.77	0.79	0.85	1.01	0.96	0.92	0.96	1.06	1.17	1.17	1.25
50%	1.00	0.92	0.88	0.85	0.84	0.91	0.94	1.01	1.20	1.13	1.07	1.13	1.26	1.39	1.37	1.48
75%	1.19	1.11	1.07	1.03	1.01	1.07	1.11	1.19	1.43	1.35	1.29	1.35	1.48	1.63	1.63	1.74
97.5%	1.55	1.47	1.44	1.39	1.36	1.41	1.49	1.58	1.93	1.75	1.74	1.82	1.96	2.20	2.15	2.29

Trends in SSB by ecoregion are given in Figure 23 and Table 15. The regional analysis was carried out using the same model applied to regional datasets. Due to the small number of stocks in each ecoregion (ranging between 6 in the Northeast Atlantic to 18 in the Greater North Sea) it wasn't possible to compute confidence intervals.

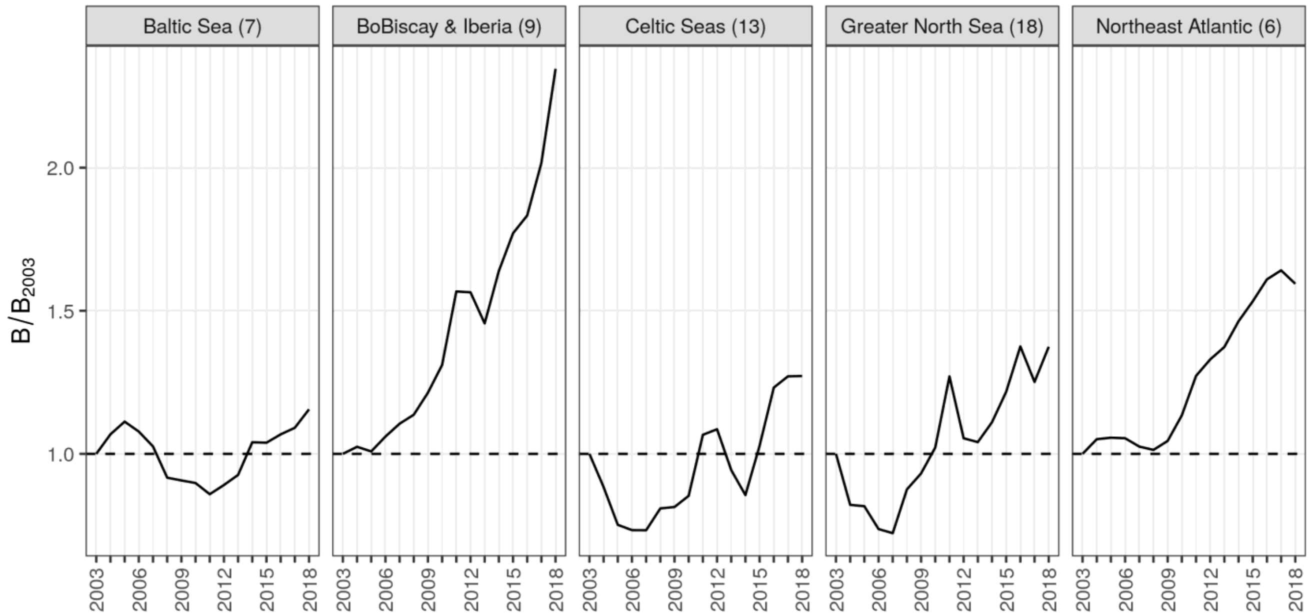


Figure 23. Trend in SSB by ecoregion relative to 2003. The number of stocks in each ecoregion are shown between parentheses.

Table 15. SSB relative to 2003 by ecoregion.

EcoRegion	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Baltic Sea	1.00	1.07	1.11	1.08	1.03	0.92	0.91	0.90	0.86	0.89	0.93	1.04	1.04	1.07	1.09	1.16
BoBiscay & Iberia	1.00	1.02	1.01	1.06	1.11	1.14	1.21	1.31	1.57	1.56	1.46	1.64	1.77	1.83	2.02	2.35
Celtic Seas	1.00	0.88	0.75	0.73	0.73	0.81	0.81	0.85	1.07	1.09	0.94	0.86	1.03	1.23	1.27	1.27
Greater North Sea	1.00	0.82	0.82	0.74	0.72	0.88	0.93	1.02	1.27	1.05	1.04	1.11	1.22	1.38	1.25	1.37
Northeast Atlantic	1.00	1.05	1.06	1.05	1.03	1.01	1.05	1.13	1.27	1.33	1.37	1.46	1.53	1.61	1.64	1.59

3.2.10 Trend in biomass data limited stocks (relative to 2003)

Figure 24 and Table 16 present the trend of biomass or abundance indices for category 3 stocks, scaled to the initial (2003) value for presentation purposes. The indicator presents a positive trend over time, which potentially reflects an increase in the biomass of these stocks.

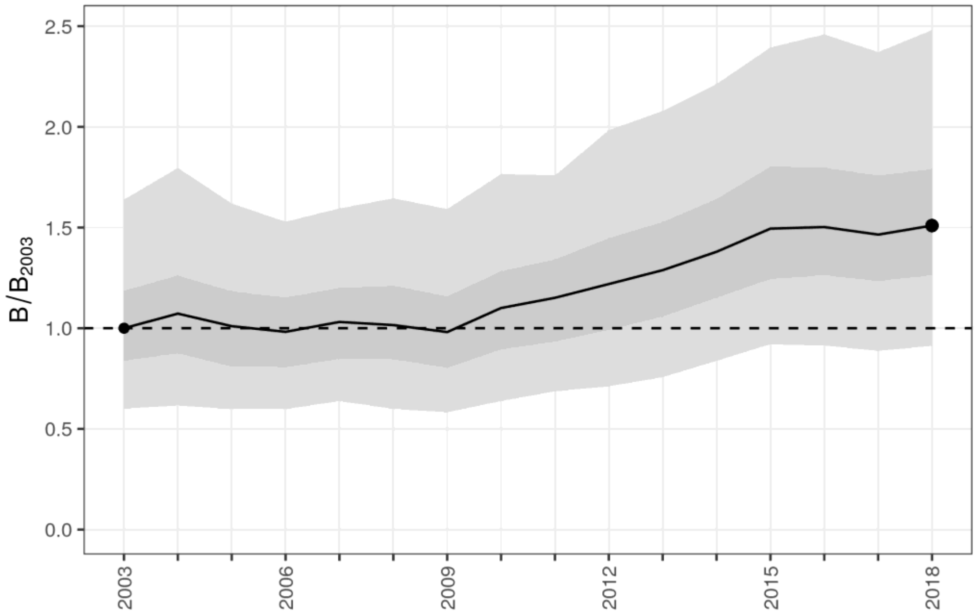


Figure 24. Trend in biomass or abundance indices relative to 2003 for data limited stocks (ICES category 3) (based on 73 stocks). Dark grey zone shows the 50% confidence interval; the light grey zone shows the 95% confidence interval.

Table 16. Percentiles for biomass or abundance indices relative to 2003 for data limited stocks (ICES category 3).

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
2.5%	0.60	0.62	0.60	0.60	0.64	0.60	0.58	0.64	0.69	0.71	0.76	0.84	0.92	0.91	0.89	0.91
25%	0.84	0.88	0.81	0.81	0.85	0.85	0.80	0.90	0.93	0.99	1.06	1.15	1.25	1.26	1.24	1.26
50%	1.00	1.07	1.01	0.98	1.03	1.02	0.98	1.10	1.15	1.22	1.29	1.38	1.49	1.50	1.46	1.51
75%	1.19	1.26	1.18	1.15	1.20	1.21	1.16	1.28	1.34	1.45	1.53	1.64	1.80	1.80	1.76	1.79
97.5%	1.64	1.80	1.62	1.53	1.59	1.65	1.59	1.77	1.76	1.98	2.08	2.21	2.39	2.46	2.37	2.48

3.2.11 Trend in recruitment (relative to 2003)

Figure 25 and Table 17 present the trend of recruitment over the period of the study, scaled to the initial (2003) value for presentation purposes. Over the time series recruitment shows a decreasing trend until 2012 and an inversion afterwards, which may reflect an increase in stock's production, although the characteristics of the indicator, a decadal ratio, makes it difficult to clearly interpret these results. For example the 2017's decadal recruitment for a single stock is the ratio between the average recruitment from 2008 to 2017 over the average recruitment from 1998 to 2007. Yearly decadal recruitment ratios for each stock constitute the dataset used to fit the model, of which predictions are afterwards scaled to 2003 (check the protocol in Annex 1 for more details).

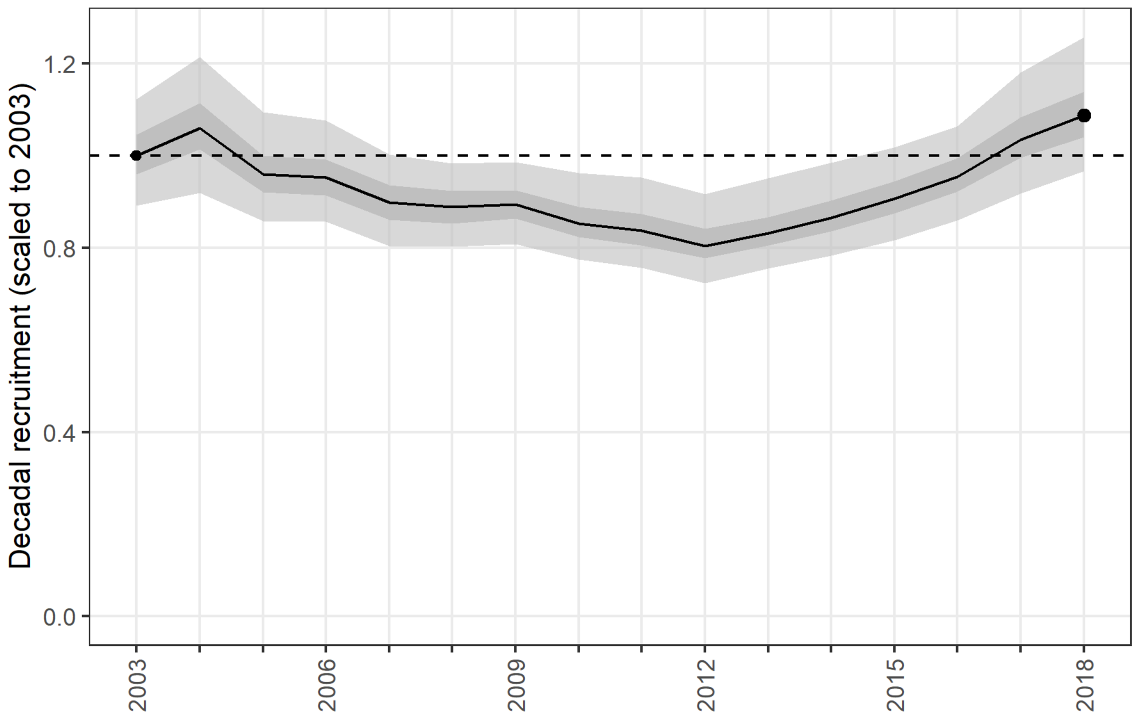


Figure 25. Trend in decadal recruitment scaled to 2003 (based on 53 stocks). Dark grey zone shows the 50% confidence interval; the light grey zone shows the 95% confidence interval.

Table 17. Percentiles for decadal recruitment scaled to 2003.

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
2.5%	0.89	0.92	0.86	0.86	0.80	0.80	0.81	0.77	0.76	0.72	0.76	0.78	0.82	0.86	0.92	0.97
25%	0.96	1.01	0.92	0.91	0.86	0.85	0.86	0.82	0.81	0.78	0.80	0.84	0.87	0.92	1.00	1.04
50%	1.00	1.06	0.96	0.95	0.90	0.89	0.89	0.85	0.84	0.80	0.83	0.87	0.91	0.95	1.03	1.09
75%	1.05	1.11	1.00	0.99	0.94	0.92	0.93	0.89	0.87	0.84	0.87	0.90	0.94	0.99	1.08	1.14
97.5%	1.12	1.21	1.09	1.08	1.00	0.98	0.99	0.96	0.95	0.92	0.95	0.98	1.02	1.06	1.18	1.26

Trends in decadal recruitment ratios by ecoregion and year are given in Figure 26 and Table 18. The regional analysis was carried out using the same model applied to regional datasets. Due to the small number of stocks in each ecoregion (ranging from 6 in the Northeast Atlantic to 17 in the Greater North Sea) it wasn't possible to compute confidence intervals.

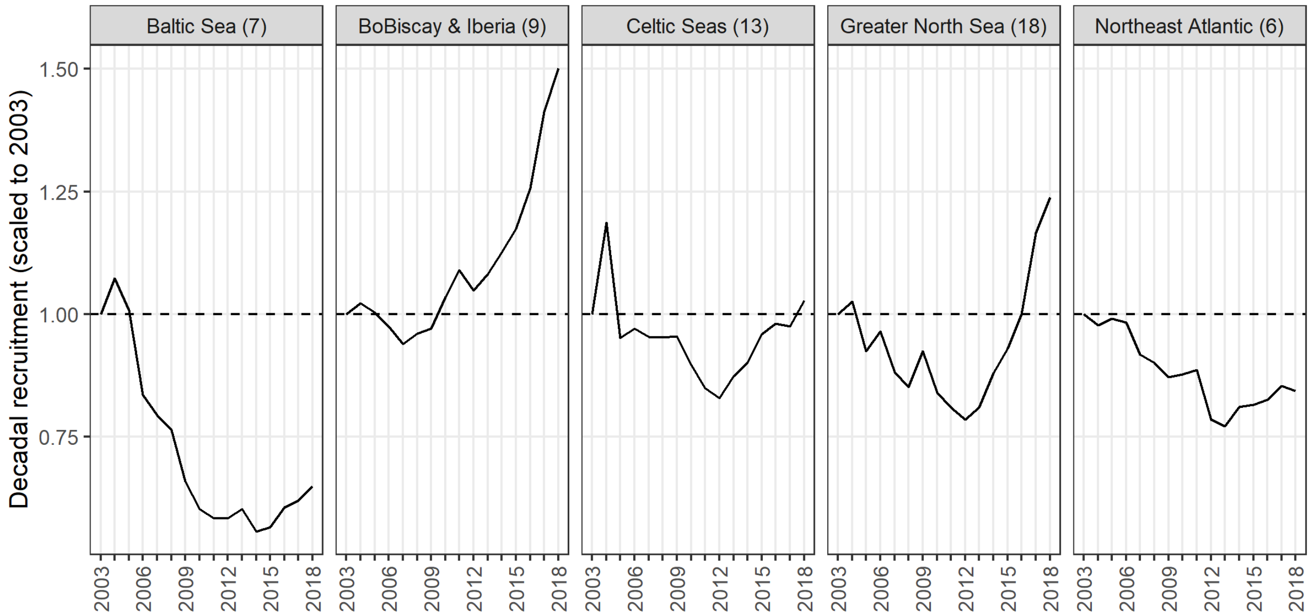


Figure 26. Trend in decadal recruitment scaled to 2003 by ecoregion. The number of stocks in each ecoregion are shown between parentheses.

Table 18. Decadal recruitment scaled to 2003 by ecoregion.

EcoRegion	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Baltic Sea	1.00	1.07	1.01	0.84	0.79	0.76	0.66	0.60	0.58	0.58	0.60	0.56	0.57	0.61	0.62	0.65
BoBiscay & Iberia	1.00	1.02	1.00	0.98	0.94	0.96	0.97	1.04	1.09	1.05	1.08	1.13	1.17	1.26	1.41	1.50
Celtic Seas	1.00	1.19	0.95	0.97	0.95	0.95	0.96	0.90	0.85	0.83	0.87	0.90	0.96	0.98	0.98	1.03
Greater North Sea	1.00	1.03	0.93	0.96	0.88	0.85	0.92	0.84	0.81	0.79	0.81	0.88	0.93	1.00	1.17	1.24
Northeast Atlantic	1.00	0.98	0.99	0.98	0.92	0.90	0.87	0.88	0.89	0.79	0.77	0.81	0.82	0.83	0.85	0.84

3.3 Indicators of advice coverage

The indicator of advice coverage computes the number of stocks for which the reference points, F_{MSY}, F_{PA}, $MSYB_{trigger}$ and B_{PA} are available and the number of associated TACs (Table 19). Note that provided part of a given TAC management area overlaps with part of a stock assessment area, the setting of the TAC is considered as being based on the relevant stock assessment. Consequently, the advice coverage indicator is biased upwards if compared with the full spatial coverage of TAC areas by stock assessments.

Table 19. Coverage of TACs by scientific advice (ICES categories 1+2).

	No of stocks	No of TACs	No of TACs based on stock assessments	Fraction of TACs based on stock assessments
Fmsy	68	156	84	0.54
MSYBtrigger	31	156	29	0.19
Fpa	45	156	71	0.46
Bpa	51	156	77	0.49

4 MEDITERRANEAN AND BLACK SEA (FAO REGION 37)

During the period 2003-2009 the number of stocks assessments available increased from 22 up to 44. The number of stock assessments was stable until 2016 and decreased to 25 in 2017 and 21 in 2018 (Figure 27 and Figure 28).

This situation renders the interpretation of the deterministic indicators misleading. With such differences in the number of stocks assessed each year, the trends in the indicators are confounded with the number of stocks available for their computation. Consequently, only the model-based indicators for trends in F/FMSY and SSB are shown.

Nevertheless, the indicator values presented (Figure 29 to Figure 32, and Table 21 to Table 24) are not very robust due to the large changes in the number of stocks available to fit the model, and therefore the results should be interpreted with caution.

Figure 27 indicates by year the number of stocks in the Mediterranean and Black Seas for which estimates of F/FMSY are available. The reduction in the number of stocks in the last two years (25 in 2017 and 21 in 2018 respectively) is due to the following reasons:

- STECF EWG part I carried out analytical assessments for 15 out of 19 stocks (STECF, 2019b)
- STECF EWG part II carried out analytical assessments for 6 out of 7 stocks (STECF, 2019c).
- STECF EWG on Black Sea stock assessments has not taken place since 2017.
- The Stock Assessment Forms (SAF) for the Black Sea assessments carried out in 2018 (having 2017 as final year) by the GFCM WGBS (WGBS meetings: Turbot Benchmark, BlackSea4Fish Steering Committee, WGBS 8, including turbot TAC) were not available on the GFCM website (http://www.fao.org/gfcm/data/safs).
- The GFCM stock assessments presented in the last WGSASP and WGSAD (2019) were not published by the time this report was written, pending review and approval by GFCM's Scientific Advisory Committee (SAC) which usually takes place in May-June of the following year (2020).
- Ten stocks were available in the GFCM SAF website (namely ARA GSA2, MUT GSA19, MUT GSA20, MUT GSA29, PAC GSA25, DPS GSA1, DPS GSA6, PIL GSA16, PIL GSA22 and ANE GSA22) but it was not possible to include them in the analysis. That is because the stock assessment outputs needed (F and SSB) were available only in graphical format and they were not provided in tables and/or in a database, such as the STECF Mediterranean database (https://stecf.jrc.ec.europa.eu/web/stecf/dd/medbs/sambs). The GFCM Secretariat clarified that what matters for the GFCM SAC is the final advice. Hence, it is not mandatory for experts attending the GFCM stock assessment groups to compile Stock Assessment Forms with the main outputs in tabular format.

Table 20 shows the stocks added to the current exercise.

Due to the reduced numbers of stock assessments available for 2018, the indicators are plotted up to 2017 only and 2018's value is plotted as stand-alone in Figure 27.

With relation to last year's report (STECF, 2019a) the following stocks were not included in the current analysis:

- Red mullet in GSA 15-16 (mut_15_16): this stock was split into two stocks, one for each area: mut_15 (Maltese Islands) and mut_16 (Strait of Sicily).

- Red mullet in Cyprus Island (mut_25): was dropped in this year's analysis as the latest assessment was done in 2016, therefore it fell outside the range used to estimate the indicators.
- Deep water rose shrimp in Alboran Sea (dps_1): was dropped in this year's analysis as the latest assessment was done in 2016, therefore it fell outside the range used to estimate the indicators.
- Striped mullet in Ligurian and North Tyrrhenian Seas (mur_9): was dropped in this year's analysis as the latest assessment was done in 2016, therefore it fell outside the range used to estimate the indicators.
- Blue and red shrimp in Ligurian and North Tyrrhenian Seas (ara_9): was replaced by the assessment for areas 9, 10 and 11 combined, ara_09-10-11.

Five new stocks were added:

- Red mullet in Maltese Islands (mut_15) and Strait of Sicily (mut_16)
- Blue and red shrimp in Ligurian and Tyrrhenian Seas (ara_09-10-11)
- Blue and red shrimp in Balearic Islands (ara_5)
- Norway lobster in Ligurian and Tyrrhenian Seas (nep_9)

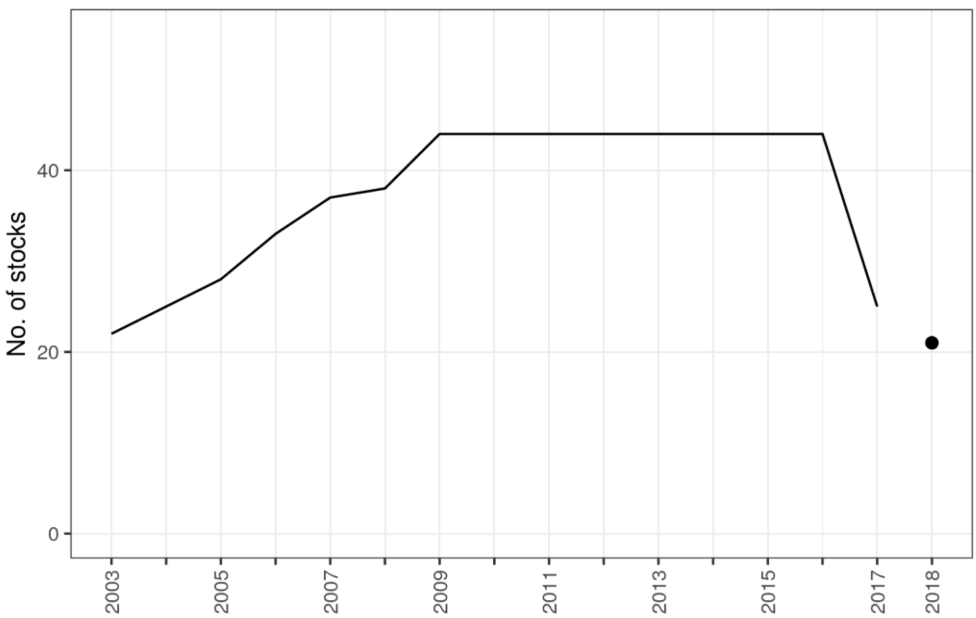


Figure 27. Number of stock assessments available in the Mediterranean and Black Sea. The totals include stocks in GSAs 1, 5-7, 9, 10-19, 22-23, 25 and 29.

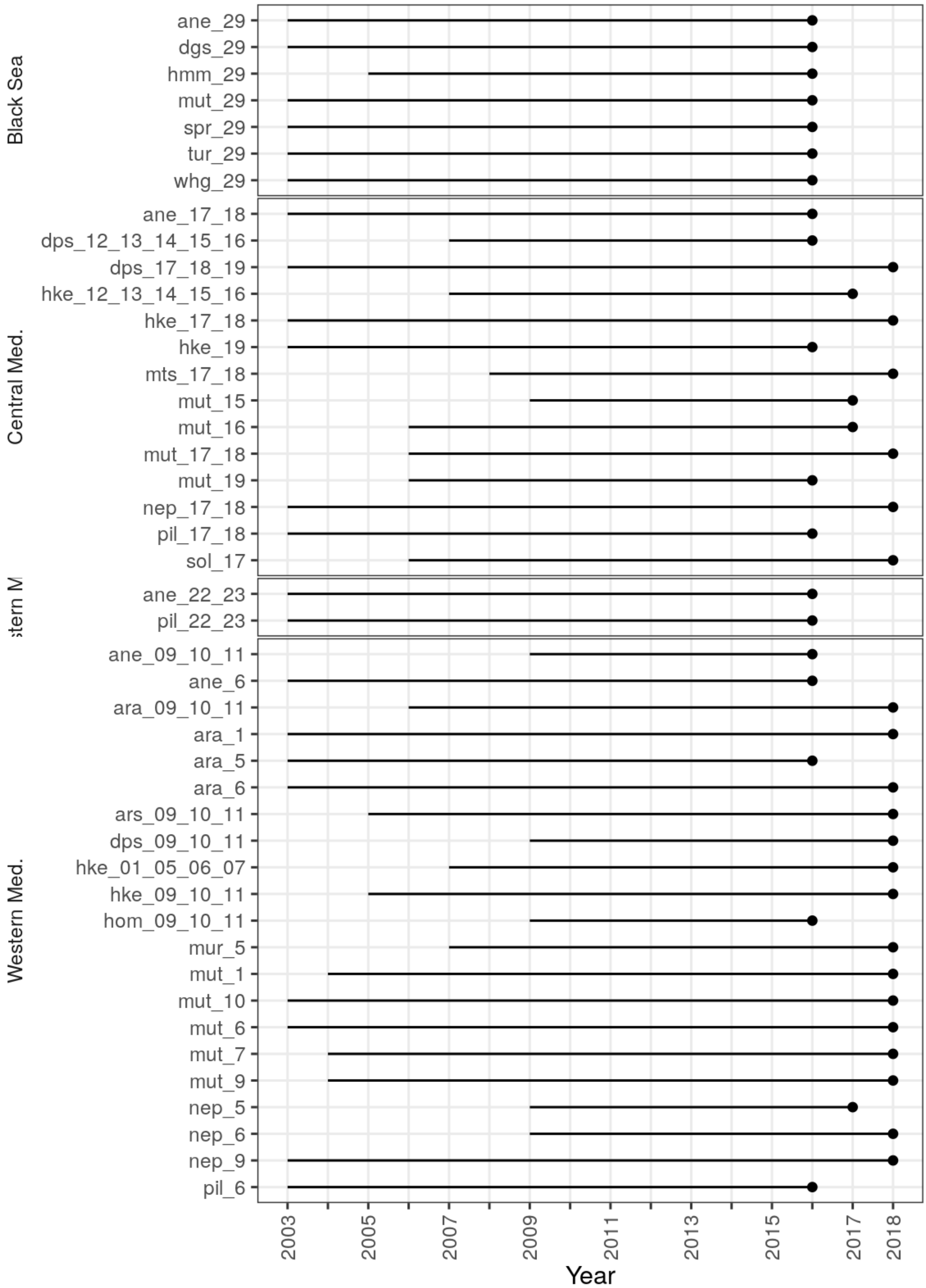


Figure 28. Time-series of stock assessments available from both STECF and GFCM for computation of model based CFP monitoring indicators for the Mediterranean and Black Seas.

Table 20. Stocks used in the current exercise.

EcoRegion	Final year	Stock	Description	Assessment year	New stock	Source
Black Sea	2016	ane_29	European anchovy in GSA 29	2017	N	STECF
Black Sea	2016	dgs_29	Piked dogfish in GSA 29	2017	N	STECF
Black Sea	2016	hmm_29	Horse mackerel in GSA 29	2017	N	STECF
Black Sea	2016	mut_29	Red mullet in GSA 29	2017	N	STECF
Black Sea	2016	spr_29	European sprat in GSA 29	2017	N	STECF
Black Sea	2016	tur_29	Turbot in GSA 29	2017	N	STECF
Black Sea	2016	whg_29	Whiting in GSA 29	2017	N	STECF
Central Med.	2016	ane_17_18	European anchovy in GSA 17_18	2017	N	GFCM
Central Med.	2016	dps_12_13_14_15_16	Deep_water rose shrimp in GSA 12_13_14_15_16	2017	N	GFCM
Central Med.	2018	dps_17_18_19	Deep-water rose shrimp in GSA 17_18_19	2019	N	STECF
Central Med.	2017	hke_12_13_14_15_16	European hake in GSA 12_13_14_15_16	2018	N	GFCM
Central Med.	2018	hke_17_18	European hake in GSA 17_18	2019	N	STECF
Central Med.	2016	hke_19	European hake in GSA 19	2017	N	STECF
Central Med.	2018	mts_17_18	Spottail mantis shrimp in GSA 17_18	2019	N	STECF
Central Med.	2017	mut_15	Red mullet in GSA 15	2018	Y	GFCM
Central Med.	2017	mut_16	Red mullet in GSA 16	2018	Y	GFCM
Central Med.	2018	mut_17_18	Red mullet in GSA 17_18	2019	N	STECF

EcoRegion	Final year	Stock	Description	Assessment year	New stock	Source
Central Med.	2016	mut_19	Red mullet in GSA 19	2017	N	STECF
Central Med.	2018	nep_17_18	Norway lobster in GSA 17_18	2019	N	STECF
Central Med.	2016	pil_17_18	Sardine in GSA 17_18	2017	N	GFCM
Central Med.	2018	sol_17	Common sole in GSA 17	2019	N	STECF
Eastern Med.	2016	ane_22_23	European anchovy in GSA 22_23	2017	N	STECF
Eastern Med.	2016	pil_22_23	Sardine in GSA 22_23	2017	N	STECF
Western Med.	2016	ane_09_10_11	European anchovy in GSA 09_10_11	2017	N	STECF
Western Med.	2016	ane_6	European anchovy in GSA 6	2017	N	STECF
Western Med.	2018	ara_09_10_11	Blue and red shrimp in GSA 09_10_11	2019	Y	STECF
Western Med.	2018	ara_1	Blue and red shrimp in GSA 1	2019	N	STECF
Western Med.	2016	ara_5	Blue and red shrimp in GSA 5	2017	Y	GFCM
Western Med.	2018	ara_6	Blue and red shrimp in GSA 6	2019	N	STECF
Western Med.	2018	ars_09_10_11	Giant red shrimp in GSA 09_10_11	2019	N	STECF
Western Med.	2018	dps_09_10_11	Deep-water rose shrimp in GSA 09_10_11	2019	N	STECF
Western Med.	2018	hke_01_05_06_07	European Hake in GSA 01_05_06_07	2019	N	STECF
Western Med.	2018	hke_09_10_11	European Hake in GSA 09_10_11	2019	N	STECF
Western Med.	2016	hom_09_10_11	Atlantic horse mackerel in GSA 09_10_11	2017	N	STECF

EcoRegion	Final year	Stock	Description	Assessment year	New stock	Source
Western Med.	2018	mur_5	Striped red mullet in GSA 5	2019	N	STECF
Western Med.	2018	mut_1	Red mullet in GSA 1	2019	N	STECF
Western Med.	2018	mut_10	Red mullet in GSA 10	2019	N	STECF
Western Med.	2018	mut_6	Red mullet in GSA 6	2019	N	STECF
Western Med.	2018	mut_7	Red mullet in GSA 7	2019	N	STECF
Western Med.	2018	mut_9	Red mullet in GSA 9	2019	N	STECF
Western Med.	2017	nep_5	Norway lobster in GSA 5	2018	N	GFCM
Western Med.	2018	nep_6	Norway lobster in GSA 6	2019	N	STECF
Western Med.	2018	nep_9	Norway lobster in GSA 9	2019	Y	STECF
Western Med.	2016	pil_6	Sardine in GSA 6	2017	N	STECF

4.1 Indicators of management performance

4.1.1 *Trend in F/F_{MSY}*

To compute this indicator a similar model to those in the North East Atlantic was used, namely a mixed linear model, described in the protocol (Annex I). Values for 2018 were removed from the model fit. Bootstrapped quantiles of F/F_{MSY} are displayed in Figure 29 and Table 21. The 50% quantile (black line, equivalent to the median) shows an overall level varying around 2.4 for the whole time series, indicating that the stocks are exploited well above the CFP management objectives. In the Mediterranean and Black Seas assessments, a more conservative proxy for F_{MSY}, $F_{0.1}$, is commonly used resulting in a higher F/F_{MSY} ratio. There is a slightly decreasing trend since 2011, from 2.7 to 2.4, which indicates a small improvement in exploitation. Nevertheless, the instability in the dataset used may have an impact in the results.

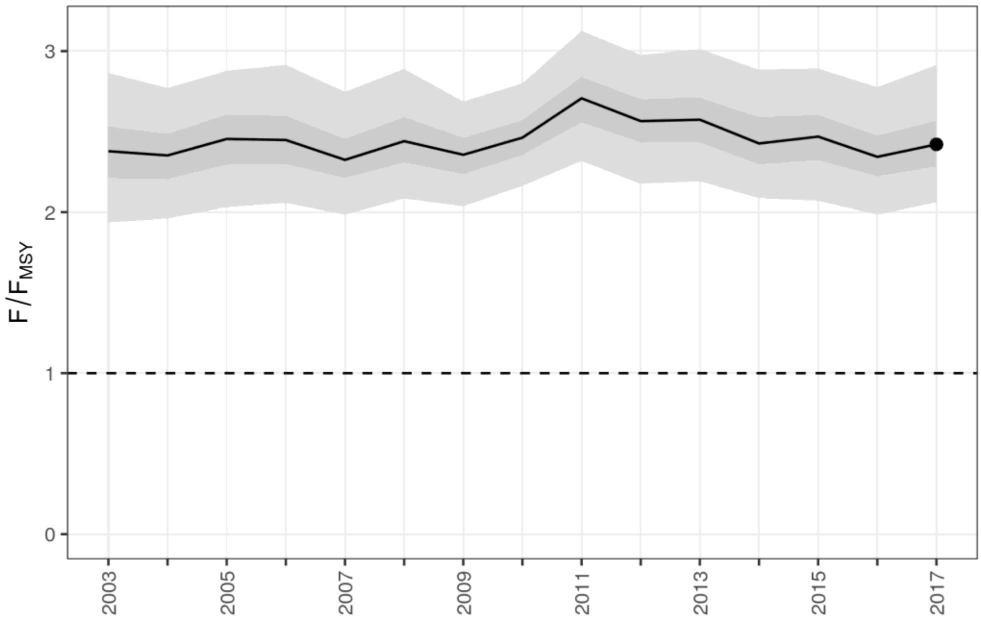


Figure 29. Trend in F/F_{MSY} (based in 44 stocks). Dark grey zone shows the 50% confidence interval; the light grey zone shows the 95% confidence interval.

Table 21. Percentiles for F/FMSY.

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
2.5%	1.94	1.96	2.03	2.06	1.98	2.08	2.04	2.16	2.32	2.18	2.19	2.09	2.07	1.98	2.06
25%	2.21	2.21	2.30	2.30	2.21	2.31	2.24	2.36	2.56	2.43	2.43	2.30	2.32	2.22	2.29
50%	2.38	2.35	2.45	2.45	2.32	2.44	2.36	2.46	2.71	2.57	2.57	2.43	2.47	2.34	2.42
75%	2.53	2.48	2.60	2.60	2.45	2.59	2.46	2.57	2.84	2.70	2.71	2.59	2.60	2.47	2.57
97.5%	2.87	2.77	2.88	2.91	2.75	2.89	2.69	2.80	3.13	2.98	3.01	2.88	2.89	2.78	2.91

Trends by ecoregion are presented in Figure 30 and Table 22. Due to the reduced number of stocks available for the Eastern Med., 2, the indicator is not shown.

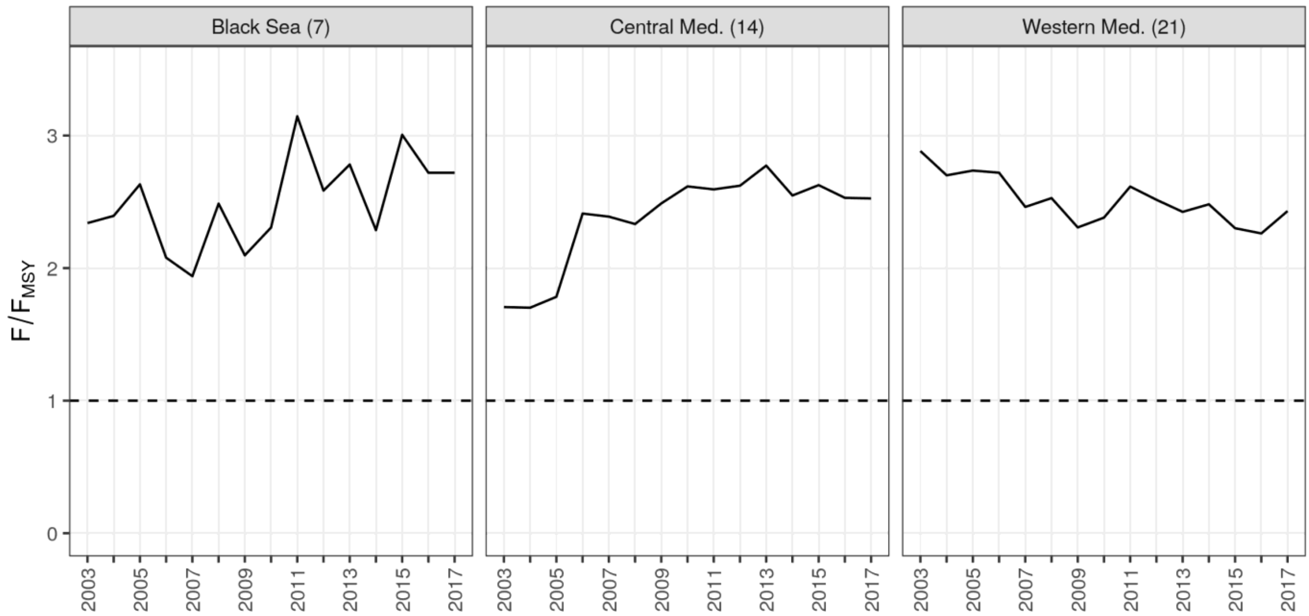


Figure 30. Trend in F/F_{MSY} by region. The number of stocks in each ecoregion are shown between parentheses.

Table 22. F/FMSY by ecoregion.

EcoRegion	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Black Sea	2.34	2.39	2.63	2.08	1.94	2.49	2.10	2.31	3.15	2.58	2.78	2.29	3.01	2.72	2.72
Cent. Med.	1.71	1.70	1.78	2.41	2.39	2.33	2.49	2.62	2.59	2.62	2.77	2.55	2.63	2.53	2.53
West Med.	2.88	2.70	2.74	2.72	2.46	2.53	2.31	2.38	2.61	2.52	2.42	2.48	2.30	2.26	2.43

4.1.2 Trend in SSB (relative to 2003)

This indicator was computed with a similar model to those in the North East Atlantic, namely a mixed linear model, described in the protocol (Annex I). The model used The 50% quantile (black line), has varied around 1 (Figure 31 and Table 23). There is no clear trend with values varying around 1 (ranged between 0.86-1.06), although it may reflect changes in the dataset available, as previously indicated. Quantiles are very large, representing a high level of uncertainty. The trends estimated by ecoregion (Figure 32 and Table 24) show the high variability between ecoregions not only in trends but mainly in the number of stocks by ecoregion as reported in the previous indicator.

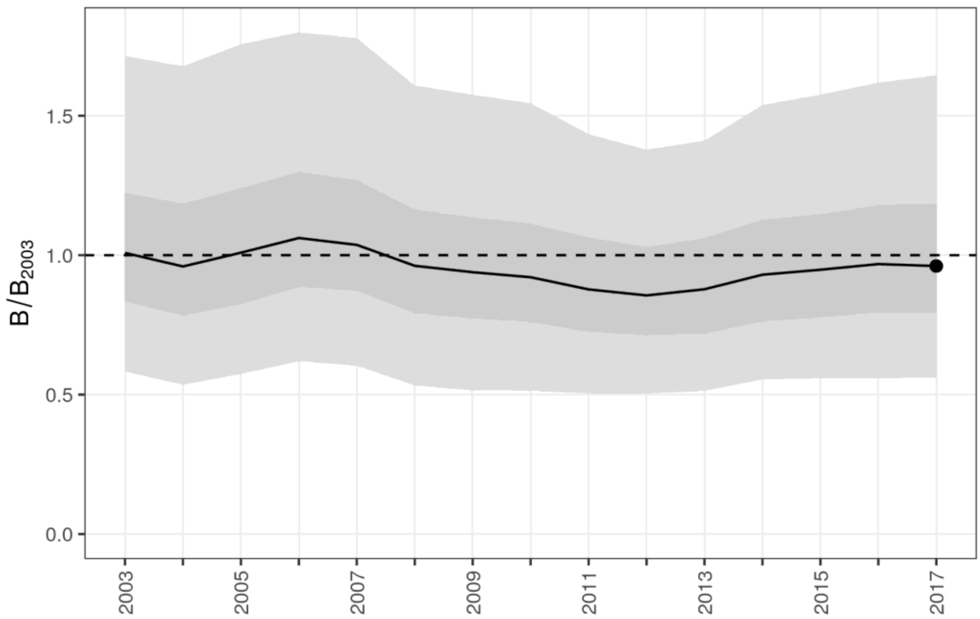


Figure 31. Trend in SSB relative to 2003 (based in 41 stocks). Dark grey zone shows the 50% confidence interval; the light grey zone shows the 95% confidence interval.

Table 23. Percentiles for SSB relative to 2003**.**

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
2.50%	0.58	0.53	0.57	0.62	0.60	0.53	0.52	0.51	0.50	0.50	0.51	0.55	0.56	0.56	0.56
25%	0.84	0.78	0.83	0.89	0.87	0.79	0.77	0.76	0.73	0.71	0.72	0.76	0.78	0.79	0.79
50%	1.00	0.96	1.01	1.06	1.04	0.96	0.94	0.92	0.88	0.86	0.88	0.93	0.95	0.97	0.96
75%	1.22	1.18	1.24	1.30	1.27	1.16	1.14	1.11	1.06	1.03	1.06	1.13	1.15	1.18	1.18
97.50%	1.71	1.68	1.76	1.80	1.78	1.61	1.58	1.55	1.43	1.38	1.41	1.54	1.58	1.62	1.65

Trends by ecoregion are presented in Figure 32 and Table 24. Due to the reduced number of stocks available for the Eastern Med., 2, the indicator is not shown.

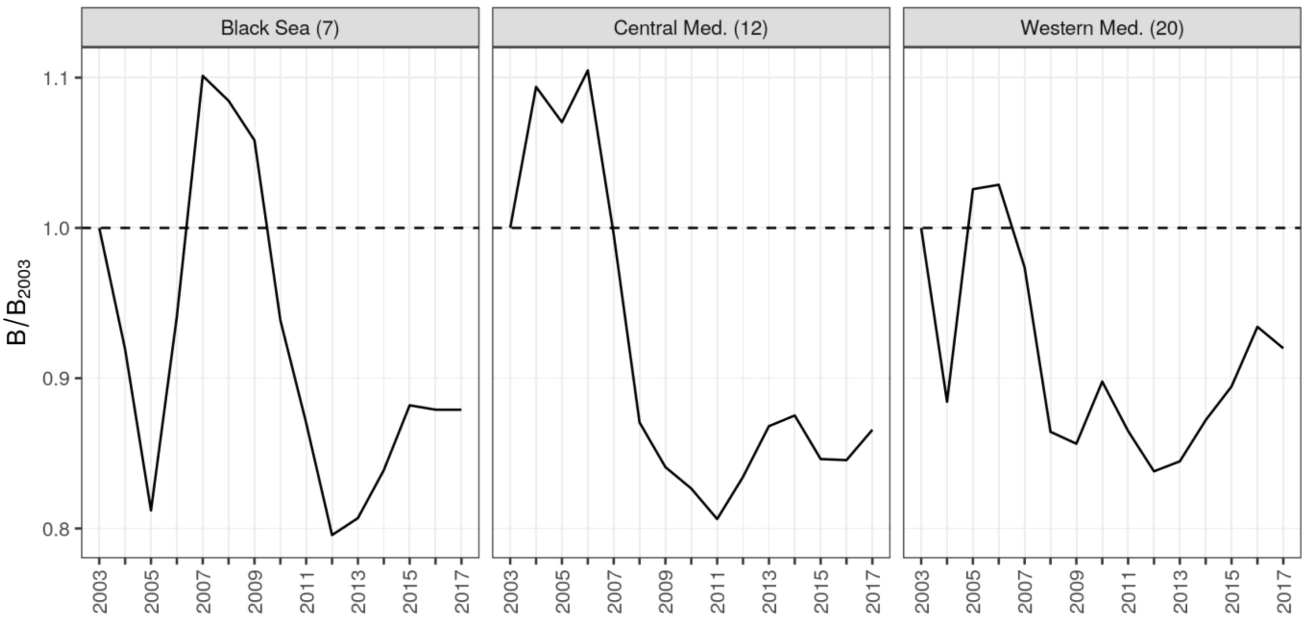


Figure 32 Trend in SSB relative to 2003 by ecoregion. The number of stocks in each ecoregion are shown between parentheses.

Table 24. SSB relative to 2003 by ecoregion**.**

EcoRegion	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Black Sea	1.00	0.92	0.81	0.94	1.10	1.08	1.06	0.94	0.87	0.80	0.81	0.84	0.88	0.88	0.88
Cent.Med.	1.00	1.09	1.07	1.10	1.00	0.87	0.84	0.83	0.81	0.83	0.87	0.88	0.85	0.85	0.87
West Med.	1.00	0.88	1.03	1.03	0.97	0.86	0.86	0.90	0.86	0.84	0.84	0.87	0.89	0.93	0.92

4.2 Indicators of advice coverage

In the Mediterranean and the Black Seas a total of 249 stocks were selected for the analysis (see the protocol in Annex 01). Of these 77 are covered by stock assessments carried out between 2017 and 2019. In some cases more than one stock were aggregated in a single multi-area stock assessment, in which case all stocks in the stock list are accounted for, hence why 44 stock assessments cover 77 stocks. The advice coverage for the Mediterranean and the Black Sea is 0.30.

5 STATUS ACROSS ALL STOCKS IN 2018

Table 25. Stock status for all stocks in the analysis. Columns refer to ecoregion, last year for which the estimated was obtained, stock code and description, value of F/F_{MSY} ratio (F ind), if F is lower than F_{MSY} (F status), if the stock is inside safe biological limits (SBL), and if the stock has F above F_{MSY} or SSB below B_{MSY} ($F\sim F_{MSY}$ v $SSB\sim B_{MSY}$). Stocks managed under escapement strategies dot not have an estimate of F/F_{MSY}. Symbol 'o' or 'Y' stands for 'YES', an empty cell or 'N' stands for 'NO' and '-' stands for unknown due to missing information**.**

Region	EcoRegion	Year	Stock	Description	F ind	F status	SBL	$F\sim F_{MSY}$ V $B\sim B_{MSY}$
FAO27	Baltic Sea	2018	cod.27.22-24	Cod (*Gadus morhua*) in subdivisions 22-24. western Baltic stock (western Baltic Sea)	1.44		N	-
FAO27	Baltic Sea	2018	her.27.20-24	Herring (*Clupea harengus*) in subdivisions 20-24. spring spawners (Skagerrak. Kattegat. and western Baltic)	1.34		N	-
FAO27	Baltic Sea	2018	her.27.25-2932	Herring (*Clupea harengus*) in subdivisions 25-29 and 32. excluding the Gulf of Riga (central Baltic Sea)	1.30		Y	-
FAO27	Baltic Sea	2018	her.27.28	Herring (*Clupea harengus*) in Subdivision 28.1 (Gulf of Riga)	0.79	o	Y	Y
FAO27	Baltic Sea	2018	ple.27.21-23	Plaice (*Pleuronectes platessa*) in subdivisions 21-23 (Kattegat. Belt Seas. and the Sound)	1.31		Y	-
FAO27	Baltic Sea	2018	sol.27.20-24	Sole (*Solea solea*) in subdivisions 20-24 (Skagerrak and Kattegat. western Baltic Sea)	1.01		N	-
FAO27	Baltic Sea	2018	spr.27.22-32	Sprat (*Sprattus sprattus*) in subdivisions 22-32 (Baltic Sea)	1.23		Y	-

Region	EcoRegion	Year	Stock	Description	F ind	F status	SBL	$F \sim F_{MSY}$ V $B \sim B_{MSY}$
FAO27	BoBiscay & Iberia	2018	ane.27.8	Anchovy (*Engraulis encrasicolus*) in Subarea 8 (Bay of Biscay)	-	o	-	-
FAO27	BoBiscay & Iberia	2018	hke.27.8c9a	Hake (*Merluccius merluccius*) in divisions 8.c and 9.a. Southern stock (Cantabrian Sea and Atlantic Iberian waters)	2.38		Y	-
FAO27	BoBiscay & Iberia	2018	hom.27.9a	Horse mackerel (*Trachurus trachurus*) in Division 9.a (Atlantic Iberian waters)	0.26	o	Y	-
FAO27	BoBiscay & Iberia	2018	ldb.27.8c9a	Four-spot megrim (*Lepidorhombus boscii*) in divisions 8.c and 9.a (southern Bay of Biscay and Atlantic Iberian waters East)	0.47	o	Y	-
FAO27	BoBiscay & Iberia	2018	meg.27.7b-k8abd	Megrim (*Lepidorhombus whiffiagonis*) in divisions 7.b-k. 8.a-b. and 8.d (west and southwest of Ireland. Bay of Biscay)	0.94	o	Y	-
FAO27	BoBiscay & Iberia	2018	meg.27.8c9a	Megrim (*Lepidorhombus whiffiagonis*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)	0.89	o	Y	-
FAO27	BoBiscay & Iberia	2018	mon.27.78abd	White anglerfish (*Lophius piscatorius*) in Subarea 7 and divisions 8.a-b and 8.d (Celtic Seas. Bay of Biscay)	0.89	o	Y	-
FAO27	BoBiscay & Iberia	2018	mon.27.8c9a	White anglerfish (*Lophius piscatorius*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)	0.39	o	Y	Y
FAO27	BoBiscay & Iberia	2018	sol.27.8ab	Sole (*Solea solea*) in divisions 8.a-b (northern and central Bay of Biscay)	1.13		Y	-

Region	EcoRegion	Year	Stock	Description	F ind	F status	SBL	F~FMSY V B~BMSY
FAO27	Celtic Seas	2018	cod.27.6a	Cod (*Gadus morhua*) in Division 6.a (West of Scotland)	2.41		N	-
FAO27	Celtic Seas	2018	cod.27.7e-k	Cod (*Gadus morhua*) in divisions 7.e-k (eastern English Channel and southern Celtic Seas)	2.36		N	-
FAO27	Celtic Seas	2018	had.27.6b	Haddock (*Melanogrammus aeglefinus*) in Division 6.b (Rockall)	0.93	o	Y	-
FAO27	Celtic Seas	2018	had.27.7a	Haddock (*Melanogrammus aeglefinus*) in Division 7.a (Irish Sea)	0.55	o	Y	Y
FAO27	Celtic Seas	2018	had.27.7b-k	Haddock (*Melanogrammus aeglefinus*) in divisions 7.b-k (southern Celtic Seas and English Channel)	1.93		Y	-
FAO27	Celtic Seas	2018	her.27.irls	Herring (*Clupea harengus*) in divisions 7.a South of 52Â°30â€™N. 7.g-h. and 7.j-k (Irish Sea. Celtic Sea. and southwest of Ireland)	1.28		N	-
FAO27	Celtic Seas	2018	her.27.nirs	Herring (*Clupea harengus*) in Division 7.a North of 52Â°30â€™N (Irish Sea)	0.59	o	Y	-
FAO27	Celtic Seas	2018	lez.27.4a6a	Megrim (*Lepidorhombus spp.*) in divisions 4.a and 6.a (northern North Sea. West of Scotland)	0.40	o	-	Y
FAO27	Celtic Seas	2018	nep.fu.11	Norway lobster (*Nephrops norvegicus*) in Division 6.a. Functional Unit 11 (West of Scotland. North Minch)	0.59	o	-	Y
FAO27	Celtic Seas	2018	nep.fu.12	Norway lobster (*Nephrops norvegicus*) in Division 6.a. Functional Unit 12 (West of Scotland. South Minch)	0.41	o	-	Y

Region	EcoRegion	Year	Stock	Description	F ind	F status	SBL	F~F$_{MSY}$ V B~B$_{MSY}$
FAO27	Celtic Seas	2018	nep.fu.13	Norway lobster (*Nephrops norvegicus*) in Division 6.a. Functional Unit 13 (West of Scotland. the Firth of Clyde and Sound of Jura)	0.73	o	-	Y
FAO27	Celtic Seas	2018	nep.fu.14	Norway lobster (*Nephrops norvegicus*) in Division 7.a. Functional Unit 14 (Irish Sea. East)	0.23	o	-	Y
FAO27	Celtic Seas	2018	nep.fu.15	Norway lobster (*Nephrops norvegicus*) in Division 7.a. Functional Unit 15 (Irish Sea. West)	0.55	o	-	Y
FAO27	Celtic Seas	2018	nep.fu.16	Norway lobster (*Nephrops norvegicus*) in divisions 7.b-c and 7.j-k. Functional Unit 16 (west and southwest of Ireland. Porcupine Bank)	0.96	o	-	-
FAO27	Celtic Seas	2018	nep.fu.17	Norway lobster (*Nephrops norvegicus*) in Division 7.b. Functional Unit 17 (west of Ireland. Aran grounds)	0.64	o	-	Y
FAO27	Celtic Seas	2018	nep.fu.19	Norway lobster (*Nephrops norvegicus*) in divisions 7.a. 7.g. and 7.j. Functional Unit 19 (Irish Sea. Celtic Sea. eastern part of southwest of Ireland)	0.66	o	-	N
FAO27	Celtic Seas	2018	nep.fu.2021	Norway lobster (*Nephrops norvegicus*) in divisions 7.g and 7.h. Functional Units 20 and 21 (Celtic Sea)	0.50	o	-	-
FAO27	Celtic Seas	2018	nep.fu.22	Norway lobster (*Nephrops norvegicus*) in divisions 7.f and 7.g. Functional Unit 22 (Celtic Sea. Bristol Channel)	1.08		-	N
FAO27	Celtic Seas	2018	ple.27.7a	Plaice (*Pleuronectes platessa*) in Division 7.a (Irish Sea)	0.33	o	Y	Y

Region	EcoRegion	Year	Stock	Description	F ind	F status	SBL	F~F_{MSY} V B~B_{MSY}
FAO27	Celtic Seas	2018	sol.27.7a	Sole (*Solea solea*) in Division 7.a (Irish Sea)	0.07	o	N	-
FAO27	Celtic Seas	2018	sol.27.7fg	Sole (*Solea solea*) in divisions 7.f and 7.g (Bristol Channel. Celtic Sea)	0.77	o	Y	-
FAO27	Celtic Seas	2017	whg.27.6a	Whiting (*Merlangius merlangus*) in Division 6.a (West of Scotland)	0.23	o	N	-
FAO27	Celtic Seas	2018	whg.27.7a	Whiting (*Merlangius merlangus*) in Division 7.a (Irish Sea)	2.12		N	-
FAO27	Celtic Seas	2018	whg.27.7b-ce-k	Whiting (*Merlangius merlangus*) in divisions 7.b-c and 7.e-k (southern Celtic Seas and eastern English Channel)	1.19		N	-
FAO27	Greater North Sea	2018	cod.27.47d20	Cod (*Gadus morhua*) in Subarea 4. Division 7.d. and Subdivision 20 (North Sea. eastern English Channel. Skagerrak)	2.06		N	-
FAO27	Greater North Sea	2018	had.27.46a20	Haddock (*Melanogrammus aeglefinus*) in Subarea 4. Division 6.a. and Subdivision 20 (North Sea. West of Scotland. Skagerrak)	1.18		Y	-
FAO27	Greater North Sea	2018	her.27.3a47d	Herring (*Clupea harengus*) in Subarea 4 and divisions 3.a and 7.d. autumn spawners (North Sea. Skagerrak and Kattegat. eastern English Channel)	0.80	o	Y	Y
FAO27	Greater North Sea	2018	nep.fu.6	Norway lobster (*Nephrops norvegicus*) in Division 4.b. Functional Unit 6 (central North Sea. Farn Deeps)	1.03		-	N
FAO27	Greater North Sea	2018	nep.fu.7	Norway lobster (*Nephrops norvegicus*) in Division 4.a. Functional Unit 7 (northern North Sea. Fladen Ground)	0.37	o	-	Y

Region	EcoRegion	Year	Stock	Description	F ind	F status	SBL	$F \sim F_{MSY}$ V $B \sim B_{MSY}$
FAO27	Greater North Sea	2018	nep.fu.8	Norway lobster (*Nephrops norvegicus*) in Division 4.b. Functional Unit 8 (central North Sea. Firth of Forth)	0.79	o	-	Y
FAO27	Greater North Sea	2018	nep.fu.9	Norway lobster (*Nephrops norvegicus*) in Division 4.a. Functional Unit 9 (central North Sea. Moray Firth)	0.99	o	-	Y
FAO27	Greater North Sea	2018	nop.27.3a4	Norway pout (*Trisopterus esmarkii*) in Subarea 4 and Division 3.a (North Sea. Skagerrak and Kattegat)	-		-	-
FAO27	Greater North Sea	2018	ple.27.420	Plaice (*Pleuronectes platessa*) in Subarea 4 (North Sea) and Subdivision 20 (Skagerrak)	0.89	o	Y	Y
FAO27	Greater North Sea	2018	ple.27.7d	Plaice (*Pleuronectes platessa*) in Division 7.d (eastern English Channel)	0.93	o	Y	-
FAO27	Greater North Sea	2018	pok.27.3a46	Saithe (*Pollachius virens*) in subareas 4. 6 and Division 3.a (North Sea. Rockall and West of Scotland. Skagerrak and Kattegat)	0.99	o	Y	-
FAO27	Greater North Sea	2018	pra.27.3a4a	Northern shrimp (*Pandalus borealis*) in divisions 3.a and 4.a East (Skagerrak and Kattegat and northern North Sea in the Norwegian Deep)	1.10		N	N
FAO27	Greater North Sea	2018	san.sa.1r	Sandeel (*Ammodytes spp.*) in divisions 4.b and 4.c. Sandeel Area 1r (central and southern North Sea. Dogger Bank)	-	o	-	-
FAO27	Greater North Sea	2018	san.sa.2r	Sandeel (*Ammodytes spp.*) in divisions 4.b and 4.c. and Subdivision 20. Sandeel Area 2r (Skagerrak. central and southern North Sea)	-	o	-	-

Region	EcoRegion	Year	Stock	Description	F ind	F status	SBL	$F \sim F_{MSY}$ V $B \sim B_{MSY}$
FAO27	Greater North Sea	2018	san.sa.3r	Sandeel (*Ammodytes spp.*) in divisions 4.a and 4.b. and Subdivision 20. Sandeel Area 3r (Skagerrak. northern and central North Sea)	-	o	-	-
FAO27	Greater North Sea	2018	san.sa.4	Sandeel (*Ammodytes spp.*) in divisions 4.a and 4.b. Sandeel Area 4 (northern and central North Sea)	-	o	-	-
FAO27	Greater North Sea	2018	sol.27.4	Sole (*Solea solea*) in Subarea 4 (North Sea)	1.08		Y	-
FAO27	Greater North Sea	2018	sol.27.7e	Sole (*Solea solea*) in Division 7.e (western English Channel)	0.78	o	Y	Y
FAO27	Greater North Sea	2018	spr.27.3a4	Sprat (*Sprattus sprattus*) in Division 3.a and Subarea 4 (Skagerrak. Kattegat and North Sea)	-	o	-	-
FAO27	Greater North Sea	2018	tur.27.4	Turbot (*Scophthalmus maximus*) in Subarea 4 (North Sea)	0.99	o	Y	Y
FAO27	Greater North Sea	2018	whg.27.47d	Whiting (*Merlangius merlangus*) in Subarea 4 and Division 7.d (North Sea and eastern English Channel)	1.16		Y	-
FAO27	Greater North Sea	2018	wit.27.3a47d	Witch (*Glyptocephalus cynoglossus*) in Subarea 4 and divisions 3.a and 7.d (North Sea. Skagerrak and Kattegat. eastern English Channel)	1.54		N	-
FAO27	Northeast Atlantic	2017	bli.27.5b67	Blue ling (*Molva dypterygia*) in subareas 6-7 and Division 5.b (Celtic Seas, English Channel, and Faroes grounds)	0.25	o	Y	-

Region	EcoRegion	Year	Stock	Description	F ind	F status	SBL	$F \sim F_{MSY}$ V $B \sim B_{MSY}$
FAO27	Northeast Atlantic	2017	dgs.27.nea	Spurdog (*Squalus acanthias*) in Subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)	0.29	o	-	N
FAO27	Northeast Atlantic	2018	hke.27.3a46-8abd	Hake (*Merluccius merluccius*) in subareas 4. 6. and 7. and divisions 3.a. 8.a-b. and 8.d. Northern stock (Greater North Sea. Celtic Seas. and the northern Bay of Biscay)	0.81	o	Y	-
FAO27	Northeast Atlantic	2018	hom.27.2a4a5b6a7a-ce-k8	Horse mackerel (*Trachurus trachurus*) in Subarea 8 and divisions 2.a. 4.a. 5.b. 6.a. 7.a-c.e-k (the Northeast Atlantic)	1.18		N	-
FAO27	Northeast Atlantic	2018	mac.27.nea	Mackerel (*Scomber scombrus*) in subareas 1-8 and 14 and Division 9.a (the Northeast Atlantic and adjacent waters)	1.03		Y	-
FAO27	Northeast Atlantic	2018	whb.27.1-91214	Blue whiting (*Micromesistius poutassou*) in subareas 1-9. 12. and 14 (Northeast Atlantic and adjacent waters)	1.23		Y	-
FAO37	Black Sea	2016	ane_29	European anchovy in GSA 29	1.29		-	-
FAO37	Black Sea	2016	dgs_29	Piked dogfish in GSA 29	11.74		-	-
FAO37	Black Sea	2016	hmm_29	Horse mackerel in GSA 29	3.66		-	-
FAO37	Black Sea	2016	mut_29	Red mullet in GSA 29	1.48		-	-
FAO37	Black Sea	2016	spr_29	European sprat in GSA 29	1.15		-	-

Region	EcoRegion	Year	Stock	Description	F ind	F status	SBL	F~F_{MSY} V B~B_{MSY}
FAO37	Black Sea	2016	tur_29	Turbot in GSA 29	3.74		-	-
FAO37	Black Sea	2016	whg_29	Whiting in GSA 29	2.32		-	-
FAO37	Central Med.	2016	ane_17_18	European anchovy in GSA 17, 18	2.23		-	-
FAO37	Central Med.	2016	dps_12_13_14_15_16	Deep_water rose shrimp in GSA 12, 13, 14, 15, 16	1.71		-	-
FAO37	Central Med.	2017	dps_17_18_19	Deep-water rose shrimp in GSA 17, 18, 19	3.06		-	-
FAO37	Central Med.	2017	hke_12_13_14_15_16	European hake in GSA 12, 13, 14, 15, 16	4.25		-	-
FAO37	Central Med.	2017	hke_17_18	European hake in GSA 17, 18	3.05		-	-
FAO37	Central Med.	2016	hke_19	European hake in GSA 19	12.14		-	-
FAO37	Central Med.	2017	mts_17_18	Spottail mantis shrimp in GSA 17, 18	2.99		-	-
FAO37	Central Med.	2017	mut_15	Red mullet in GSA 15	1.30		-	-
FAO37	Central Med.	2017	mut_16	Red mullet in GSA 16	1.03		-	-
FAO37	Central Med.	2017	mut_17_18	Red mullet in GSA 17, 18	1.61		-	-

Region	EcoRegion	Year	Stock	Description	F ind	F status	SBL	$F \sim F_{MSY}$ V $B \sim B_{MSY}$
FAO37	Central Med.	2016	mut_19	Red mullet in GSA 19	1.56		-	-
FAO37	Central Med.	2017	nep_17_18	Norway lobster in GSA 17, 18	1.47		-	-
FAO37	Central Med.	2016	pil_17_18	Sardine in GSA 17, 18	2.77		-	-
FAO37	Central Med.	2017	sol_17	Common sole in GSA 17	3.48		-	-
FAO37	Eastern Med.	2016	ane_22_23	European anchovy in GSA 22, 23	0.99	o	-	-
FAO37	Eastern Med.	2016	pil_22_23	Sardine in GSA 22, 23	1.06		-	-
FAO37	Western Med.	2016	ane_09_10_11	European anchovy in GSA 09, 10, 11	1.53		-	-
FAO37	Western Med.	2016	ane_6	European anchovy in GSA 6	1.19		-	-
FAO37	Western Med.	2017	ara_09_10_11	Blue and red shrimp in GSA 09, 10, 11	2.23		-	-
FAO37	Western Med.	2017	ara_1	Blue and red shrimp in GSA 1	1.78		-	-
FAO37	Western Med.	2016	ara_5	Blue and red shrimp in GSA 5	1.48		-	-
FAO37	Western Med.	2017	ara_6	Blue and red shrimp in GSA 6	3.85		-	-

Region	EcoRegion	Year	Stock	Description	F ind	F status	SBL	$F \sim F_{MSY}$ V $B \sim B_{MSY}$
FAO37	Western Med.	2017	ars_09_10_11	Giant red shrimp in GSA 09, 10, 11	1.58		-	-
FAO37	Western Med.	2017	dps_09_10_11	Deep-water rose shrimp in GSA 09, 10, 11	0.87	o	-	-
FAO37	Western Med.	2017	hke_01_05_06_07	European Hake in GSA 01, 05, 06, 07	4.79		-	-
FAO37	Western Med.	2017	hke_09_10_11	European Hake in GSA 09, 10, 11	3.14		-	-
FAO37	Western Med.	2016	hom_09_10_11	Atlantic horse mackerel in GSA 09, 10, 11	2.43		-	-
FAO37	Western Med.	2017	mur_5	Striped red mullet in GSA 5	1.60		-	-
FAO37	Western Med.	2017	mut_1	Red mullet in GSA 1	3.02		-	-
FAO37	Western Med.	2017	mut_10	Red mullet in GSA 10	1.34		-	-
FAO37	Western Med.	2017	mut_6	Red mullet in GSA 6	4.44		-	-
FAO37	Western Med.	2017	mut_7	Red mullet in GSA 7	1.90		-	-
FAO37	Western Med.	2017	mut_9	Red mullet in GSA 9	2.48		-	-
FAO37	Western Med.	2017	nep_5	Norway lobster in GSA 5	7.60		-	-

Region	EcoRegion	Year	Stock	Description	F ind	F status	SBL	F~F$_{MSY}$ V B~B$_{MSY}$
FAO37	Western Med.	2017	nep_6	Norway lobster in GSA 6	7.27		-	-
FAO37	Western Med.	2017	nep_9	Norway lobster in GSA 9	1.00	o	-	-
FAO37	Western Med.	2016	pil_6	Sardine in GSA 6	2.57		-	-

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7 CONTACT DETAILS OF EWG-ADHOC-19-01 PARTICIPANTS

[1] - Information on EWG participant's affiliations is displayed for information only. In any case, Members of the STECF, invited experts, and JRC experts shall act independently. In the context of the STECF work, the committee members and other experts do not represent the institutions/bodies they are affiliated to in their daily jobs. STECF members and experts also declare at each meeting of the STECF and of its Expert Working Groups any specific interest which might be considered prejudicial to their independence in relation to specific items on the agenda. These declarations are displayed on the public meeting's website if experts explicitly authorized the JRC to do so in accordance with EU legislation on the protection of personnel data. For more information: http://stecf.jrc.ec.europa.eu/adm-declarations

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8 LIST OF ANNEXES

Electronic annexes are published on the meeting's web site on:
https://stecf.jrc.ec.europa.eu/reports/cfp-monitoring

List of electronic annexes documents:

EWG - Adhoc - 20-01 – Annex 1 – URL links to the source reports by stock

EWG - Adhoc - 20-01 – Annex 2 – ICES data quality issues corrected prior to the analysis

EWG - Adhoc - 20-01 – Annex 3 – Indicator's stability tests

9 BACKGROUND DOCUMENT

EWG-Adhoc-20-01 – Doc 1 - Declarations of JRC experts (see also section 7 of this report – List of participants)

10 ANNEX 1 – PROTOCOL

Protocol for the Monitoring of the Common Fisheries Policy
Version 4.0

January 31, 2019

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Contents

1 Introduction

The monitoring of the Common Fisheries Policy (CFP, Reg (EU) 1380/2013) implementation is of utmost importance for the European Union (EU), European Commission (EC) and its Directorate-General for Maritime Affairs and Fisheries (DG MARE).

The European Commission Scientific, Technical and Economic Committee for Fisheries (STECF), as the major scientific advisory body on fisheries policy to the EC, has the task of reporting on the CFP implementation through the estimation and publication of a series of indicators.

To make the process as consistent as possible, the following set of rules were developed to be used as a guiding protocol for computing the required indicators. The rules also contribute to the transparency of the process.

The protocol covers the three major elements in the process:

- Data issues: data sources, reference list of stocks, selection of stocks, etc;
- Indicators of management performance: description of the indicators, procedures for their computation and presentation format;
- Indicators of changes in advice coverage: description of the indicators, procedures for their computation and presentation format.

1.1 Scope

The monitoring of the CFP should cover all areas were fleets operate under the flag of any EU member state. However, due to limitations on data and the mitigated responsibility of the EU on management decisions on waters outside the EU EEZ (Exclusive Economic Zone), the analysis will mainly focus on stocks within the EU EEZ in the FAO areas 27 (NEA: Northeast Atlantic and Adjacent Seas) and 37 (MED: Mediterranean and Black Sea).

The analysis will have two perspectives, at the global EU level and a regional overview where the indicators are computed for the following regions, if enough data is available:

- Baltic Sea (NEA)
- Greater North Sea (NEA)
- Celtic Sea (NEA)
- Bay of Biscay and Iberian Waters (NEA)
- Widely distributed stocks (NEA)
- Western Mediterranean (MED)
- Eastern Mediterranean (MED)
- Central Mediterranean (MED)
- Black Sea (MED)

1.2 Definitions

- f or F represent fishing mortality;
- b or B represent biomass, either as total stock biomass or spawning stock biomass (SSB);
- k represents a standardized biomass index, which is considered by experts to represent the evolution of biomass over time;
- r represents recruitment (young individuals entering the fishery) in number of individuals;

- F_{MSY} represents fishing mortality that produces catches at the level of MSY in an equilibrium situation, or a proxy;
- F_{PA} is the precautionary reference point for fishing mortality;
- B_{MSY} is the biomass expected to produce MSY when fished at F_{MSY} in an equilibrium situation, but also any other relevant proxy considered by the scientific advice body;
- B_{PA} is the precautionary reference point for spawning stock biomass;
- indices:
  - $j = 1 \ldots N$ indexes stocks, where N is the total number of stocks selected for the analysis;
  - $t = 1 \ldots T$ indexes years, where T is the number of years in the reported time series;
  - $m = 1 \ldots M$ indexes sampling units, where M is the total number of stocks in the reference list;
  - $s = 1 \ldots S$ indexes bootstrap simulations;
- operations:
  - $\vee$ stands for *or* in Boolean logic;
  - $\wedge$ stands for *and* in Boolean logic;
- model parameters:
  - u is a random effect in stock;
  - y is a fixed effect in year.

2 Data

2.1 Data sources

All indicators are computed using results from single species quantitative stock assessments. Time series of estimates of fishing mortality, spawning stock biomass, and the adopted biological reference points for each stock are to be provided by the International Council for the Exploration of the Sea (ICES), the General Fisheries Commission for the Mediterranean (GFCM) and STECF.

Results from surplus production models and delay-difference models, which are mostly reported as ratios between F and F_{MSY} and/or B over B_{MSY}, are also included in the analysis.

Results from pseudo-cohort analysis and similar methods are not included. These models do not estimate time series of fishing mortality or spawning stock biomass.

Results from methods that directly estimate total abundance and/or harvest rate may be used for the computation of some indicators.

2.2 Reference list of stocks

The list of stocks to be used for computing indicators, hereafter termed the *reference list*, is used to stabilize the basis on which the indicators are computed. It assures that the relevant stocks are considered and constitutes the base for computing the scientific coverage of the advise. The reference list must include at least those stocks that are subject to direct management from the EU, as changes in their status can be linked more clearly to the implementation of the CFP.

Because of the differences in the nature and availability of data and information in different regions, region-specific reference lists were adopted for the EU waters:

- Northeast Atlantic (FAO area 27): The list of stocks comprises all stocks subject to management by Total Allowable Catch (TAC) limits.

- Mediterranean and Black Sea (FAO area 37): the list of stocks comprises all stocks of the species
  - anchovy (*Engraulis encrasicolus*)
  - blackbellied angler (*Lophius budegassa*)
  - blue and red shrimp (*Aristeus antennatus*)
  - giant red shrimp (*Aristaeomorpha foliacea*)
  - deep-water rose shrimp (*Parapenaeus longirostriss*)
  - hake (*Merluccius merluccius*)
  - striped red mullet (*Mullus surmuletus*)
  - red mullet (*Mullus barbatus*)
  - Norway lobster (*Nephrops norvegicus*)
  - sardine (*Sardina pilchardus*)
  - common sole (*Solea solea*)
  - sprat (*Sprattus sprattus*)
  - turbot (*Psetta maxima*)
  - blue whiting (*Micromesistius poutassou*)
  - whiting (*Merlangius merlangus*)

  plus the stocks ranked in the top ten in either landings or reported economic value over the 2012-2014 period.

2.3 Selection of stock assessments

- The stock assessments to be selected include all stock assessments carried out in the three years before the analysis, are listed in the reference list and have at least 5 years of estimates.
- Exploratory assessments or assessments not yet approved by the advisory bodies are not considered;
- When several stocks are merged in a single stock only the aggregated stock is considered, the reference list must be updated accordingly;
- When a stock is split in two (or more) stocks only the disaggregated stocks are considered, the reference list must be updated accordingly;
- If two assessments for the same stock exist the most recent one is kept.
- if two assessments in the same year for the same stock exist the one from the relevant RFMO is kept.

Selected stocks of which the stock assessment results don't cover the recent period of evaluation, the most recent estimates available will be kept constant and replicated up to the most recent year of the analysis.

3 Indicators of management performance

The indicators employed to monitor the performance of the CFP management regime reflect the evolution of exploitation status and conservation status.

The first group of indicators build a historical perspective by simply counting the number of stocks above/below a defined treshold in each year. A second group of indicators model a trend over time with a Generalized Linear Mixed Model (GLMM), using *stock* as a random effect, *year* as a fixed effect, and a Gamma distribution with a *log* link. The indicator is the model prediction of the *year* effect, and the indicator's uncertainty is computed with a block bootstrap procedure using *stock* as blocks. This model was tested in a simulation study[1] and in an application to Mediterranean stocks[2].

[1] Minto, C. 2015. Testing model based indicators for monitoring the CFP performance. Ad-hoc contract report, pp 14.

[2] Chato-Osio, G., Jardim, E., Minto, C., Scott, F. and Patterson, K. 2015. Model based CFP indicators, F/F_{MSY} and SSB. Mediterranean region case study. JRC Technical Report No XX, pp 26.

3.1 Number of stocks where fishing mortality exceeds F_{MSY}

$$I_t = \sum_{j=1}^{j=N} (f_{jt} > F_{MSY})$$

3.2 Number of stocks where fishing mortality is equal to or less than F_{MSY}

$$I_t = \sum_{j=1}^{j=N} (f_{jt} \leq F_{MSY})$$

3.3 Number of stocks outside safe biological limits

$$I_t = \sum_{j=1}^{j=N} (f_{jt} > F_{PA} \vee b_{jt} < B_{PA})$$

3.4 Number of stocks inside safe biological limits

$$I_t = \sum_{j=1}^{j=N} (f_{jt} \leq F_{PA} \wedge b_{jt} \geq B_{PA})$$

3.5 Number of stocks where F is above F_{MSY} or SSB is below B_{MSY}

$$I_t = \sum_{j=1}^{j=N} (f_{jt} > F_{MSY} \vee b_{jt} < B_{MSY})$$

where in FAO 27

$$B_{MSY} = MSYB_{trigger}$$

3.6 Number of stocks where F is below or equal to F_{MSY} and SSB is above or equal to B_{MSY}

$$I_t = \sum_{j=1}^{j=N} (f_{jt} \leq F_{MSY} \wedge b_{jt} \geq B_{MSY})$$

where in FAO 27

$$B_{MSY} = MSYB_{trigger}$$

3.7 Trend in F/F_{MSY}

For these indicators stocks managed under escapement strategies and stocks for which fishing mortality was reported as a harvest rate are not included.

$$I_t = y_t$$

$$z_{jt} = \beta_0 + y_t + u_j$$

where

$$z_{jt} = \log E[\frac{f_{jt}}{F_{MSY}}]$$

and

$$\frac{f_{jt}}{F_{MSY}} \sim Gamma(\alpha, \beta)$$

3.8 Trend in SSB

For this indicator stocks for which biomass was reported as a relative value or total abundance are not included. This indicator is scaled to the 2003 estimate for presentational purposes.

$$I_t = median(\exp(\log y_{ts} - S^{-1} \sum_{s=1}^{s=S} \log y_{2003,s}))$$

$$z_{jt} = \beta_0 + y_t + u_j$$

where

$$z_{jt} = \log E[b_{jt}]$$

and

$$b_{jt} \sim Gamma(\alpha, \beta)$$

3.9 Trend in recruitment

The indicator is computed using the ratio between the average decadal recruitment of two following decades. For each year the previous decade and the decade before are used. The time window moves with years as such building the time series used for the indicator.

$$I_t = y_t$$

$$z_{jt} = \beta_0 + y_t + u_j$$

where

$$z_{jt} = \log E[d_{jt}]$$

and

$$d_{jt} = \frac{\sum_{t=1}^{t=-10} r_j t}{\sum_{t=-11}^{t=-20} r_j t}$$

and

$$d_{jt} \sim Gamma(\alpha, \beta)$$

3.10 Trend in biomass for data limited stocks

This indicator uses biomass indices computed from scientific surveys or CPUE (catch per unit of effort) considered by experts to represent the evolution of biomass in time. The data is build from the list of biomass indices published by ICES for data limited stocks category 3.

The indicator is calculated on a model-based form only,

$$I_t = y_t$$

$$z_{jt} = \beta_0 + y_t + u_j$$

where

$$z_{jt} = \log E[k_{jt}]$$

and

$$k_{jt} \sim Gamma(\alpha, \beta)$$

4 Indicators of changes in advice coverage

These indicators are computed for the last year of the analysis only.

4.1 Number of stocks for which estimates of F_{MSY} exist

$$I = \sum_{j=1}^{j=N} (x_j = \lambda)$$

$$\lambda = \begin{cases} x = 1 & F_{MSY}\, exists \\ x = 0 & otherwise \end{cases}$$

4.2 Number of stocks for which estimates of B_{PA} exist

$$I = \sum_{j=1}^{j=N} (x_j = \lambda)$$

$$\lambda = \begin{cases} x = 1 & B_{PA}\, exists \\ x = 0 & otherwise \end{cases}$$

4.3 Number of stocks for which estimates of B_{MSY} exist

$$I = \sum_{j=1}^{j=N} (x_j = \lambda)$$

$$\lambda = \begin{cases} x = 1 & B_{MSY}\, exists \\ x = 0 & otherwise \end{cases}$$

4.4 Fraction of TACs covered by stock assessments

This indicator considers that a sampling frame unit is covered by a stock assessment if there is at least a partial overlap between its spatial distribution and the spatial distribution of the stock.

$$I = M^{-1} \sum_{m=1}^{m=M} (x_m = \lambda)$$

$$\lambda = \begin{cases} x = 1 & spatial\, overlap\, exists \\ x = 0 & otherwise \end{cases}$$

5 Transparency

Changes or additions to this protocol shall be approved by STECF.

To promote transparency of scientific advice and allow the public in general, and stakeholders in particular, to have access to the data and analysis carried out, all code and data part of this analysis must be published online once approved by the STECF plenary.

11 Annex 2a – NEA code

```
#####################################################################
# EJ(20190319)
# NEA indicators
#####################################################################

library(ggplot2)
library(lme4)
library(influence.ME)
library(lattice)
library(parallel)
library(rgdal)
library(reshape2)
library(plyr)
source("funs.R")

#====================================================================
# Setup
#====================================================================

# year when assessments were performed
assessmentYear <- 2019
# final data year with estimations from stock assessments
fnlYear <- assessmentYear - 1
# initial data year with estimations from stock assessments
iniYear <- 2003
# vector of years
dy <- iniYear:fnlYear
# vector of years for valid assessments
vay <- (assessmentYear-2):assessmentYear
# vector of years for stock status projection
vpy <- (fnlYear-2):fnlYear
# options for reading data
options(stringsAsFactors=FALSE)
# number of simulations for mle bootstrap
it <- 500
# number of cores for mle bootstrap parallel
nc <- 10
# quantiles to be computed
qtl <- c(0.025, 0.25, 0.50, 0.75, 0.975)
# to control de seed in mclapply
RNGkind("L'Ecuyer-CMRG")
set.seed(1234)
# to make plots consistent
vp <- dy
vp[c(2,3,5,6,8,9,11,12,14,15)] <- ""
theme_set(theme_bw())
sc <- scale_x_continuous(breaks=dy, labels=as.character(vp))
th <- theme(axis.text.x  = element_text(angle=90, vjust=0.5), panel.grid.minor =
element_blank())

#====================================================================
# load & pre-process
#====================================================================

#--------------------------------------------------------------------
# assessments
#--------------------------------------------------------------------
isa <- read.csv("../data/ices/Dataset_2020.csv", stringsAsFactors=FALSE)
#isa$FishingPressure <- as.numeric(isa$FishingPressure)

# extract the main ecoregion but keep the list
er <- strsplit(isa[,"EcoRegion"], ",")
isa$EcoRegionList <- isa$EcoRegion
isa$EcoRegion <- unlist(lapply(er, function(x) x[1]))
er <- strsplit(isa[,"EcoRegion"], " ")
isa$EcoRegion <- unlist(lapply(er, function(x) paste(x[-length(x)], collapse=" ")))
isa[isa$EcoRegion=="Bay of Biscay and the Iberian Coast", "EcoRegion"] <- "BoBiscay &
Iberia"

# widely distributed to keep coherent with previous years (taken from 2017's files)
# >>> old codes don't exist anymore, updated to new ones
# isa[isa$OldFishStock %in% c("arg-rest", "bli-5b67", "boc-nea", "bsf-nea", "dgs-nea",
"gfb-comb", "her-noss", "hke-nrtn", "hom-west", "lin-oth", "mac-nea", "rng-5b67", "smn-
dp", "trk-nea", "usk-oth", "whb-comb"), "EcoRegion"] <- "Northeast Atlantic"
# This code was run in 2019 exercise
# write.csv(unique(isa[isa$OldFishStock %in% c("arg-rest", "bli-5b67", "boc-nea", "bsf-
nea", "dgs-nea", "gfb-comb", "her-noss", "hke-nrtn", "hom-west", "lin-oth", "mac-nea",
"rng-5b67", "smn-dp", "trk-nea", "usk-oth", "whb-comb"),c("OldFishStock",
```

```
"FishStock")]), file="widelyDistributed.csv")
isa[isa$FishStock %in% c("dgs.27.nea", "aru.27.6b7-1012", "bli.27.5b67", "hke.
27.3a46-8abd", "mac.27.nea", "whb.27.1-91214", "hom.27.2a4a5b6a7a-ce-k8", "reb.
2127.dp", "lin.27.3a4a6-91214", "usk.27.3a45b6a7-912b", "rng.27.5b6712b", "bsf.27.nea",
"her.27.1-24a514a", "boc.27.6-8", "sdv.27.nea", "gfb.27.nea"), "EcoRegion"] <-
"Northeast Atlantic"

# a couple of stocks that need fixing
# correcting Greater North Sea
isa[isa$FishStock %in% c("had.27.46a20", "pok.27.3a46", "sol.27.7e"), "EcoRegion"] <-
"Greater North Sea"

# fix codes for stock size and fishing mortality
isa[isa$FishingPressureDescription %in% c("Harvest Rate", "Harvest rate"),
"FishingPressureDescription"] <- "HR"

# order by year
isa <- isa[order(isa$Year),]

# reporting stk by data category
stBydc <- unique(subset(isa, Year %in% vpy)[,c("FishStock", "DataCategory",
"EcoRegion")])
stBydc <- transform(stBydc, cat=as.integer(DataCategory))
write.csv(table(stBydc[,c("EcoRegion","cat")]), file="stBydc.csv")

#-------------------------------------------------------------------
# ICES rectangles data
#-------------------------------------------------------------------

rectangles <- readOGR("../data/ices_areas", layer=
"ICES_StatRec_map_Areas_Full_20170124")
rectangles <- rectangles@data[,c("Area_27", "AreasList", "ICESNAME")]
colnames(rectangles) <- c("Max_Area","Area_List", "Rectangle")
rectangles <- subset(rectangles, !is.na(Max_Area))
# A new column is added based on Max_Area so that it is comparable across the other
data sets
rectangles$Area <- paste("27.",toupper(as.character(rectangles$Max_Area)),sep="")
# Check that each rectangle is unique and only appears once in the data
# i.e. each rectangle is uniquely assigned to one area
length(unique(rectangles$Rectangle)) == nrow(rectangles)

#-------------------------------------------------------------------
# sampling frame (TACs)
#-------------------------------------------------------------------

load("../data/ices/sframe.RData")
# fmz is the frame of all TACs
# For consistency
colnames(fmz)[colnames(fmz) == "area"] <- "Area"
colnames(fmz)[colnames(fmz) == "spp"] <- "Species"
colnames(fmz)[colnames(fmz) == "stock_id"] <- "TAC_id"
sframe <- subset(fmz, TAC_id %in% sframe_TAC)

# Each ICES area should only appear once for each FMZ stock (to prevent the appearance
of duplicate rectangles when merging with the ICES rectangle data later). We check this
here:

unarea <- daply(sframe, .(TAC_id), function(x){
    return(length(unique(x$Area))==nrow(x))
})
all(unarea)

#===================================================================
# Stocks to retain
# matches sampling frame and ICES assessments through ICES rectangles
#===================================================================

#-------------------------------------------------------------------
# subset assessments and ecoregions, add areas
#-------------------------------------------------------------------

# remove 3+
cols <- c("FishStock","ICES.Areas..splited.with.character....." , "SpeciesName",
"SGName", "DataCategory", "EcoRegion")
isa12 <- isa[isa$DataCategory<3, cols]

# NOTE: should do these fixes to isa and after subset to isa12
colnames(isa12)[colnames(isa12) == "ICES.Areas..splited.with.character....."] <- "Areas"
```

```
# Drop duplicates
isa12 <- unique(isa12)
# Remove white space and any capital letters from assessment name
isa12[,"FishStock"] <- tolower(gsub("\\s", "", isa12[,"FishStock"]))
# Make a species column from the assessment name
spp <- strsplit(isa12[,"FishStock"], "\\.")
isa12$Species <- toupper(unlist(lapply(spp, function(x) x[1])))
# Split ICES area by ~
areas <- strsplit(isa12[,"Areas"], "~")
names(areas) <- isa12[,"FishStock"]
areas <- melt(areas)
colnames(areas) <- c("Area","FishStock")
isa12 <- merge(isa12, areas)
# keep relevant columns only
isa12 <- isa12[,c("FishStock","Area", "Species", "SpeciesName", "SGName",
"DataCategory", "EcoRegion")]
isa12[,"Area"] <- toupper(gsub("\\s", "", isa12[,"Area"]))
# remove ecoregions outside EU waters
isa12 <- subset(isa12, !(EcoRegion %in% c("Arctic Ocean", "Greenland Sea", "Faroes",
"Iceland Sea")))
# drop if ecoregion is NA
isa12 <- subset(isa12, !is.na(EcoRegion))
# remove her-noss which is widely distributed but mainly norway
isa12 <- subset(isa12, FishStock!="her.27.1-24a514a")

#------------------------------------------------------------------
# fix area codes
#------------------------------------------------------------------

# fix Baltic area codes
rectangles[rectangles$Area == "27.3.A.20","Area"] <- "27.3.A"
rectangles[rectangles$Area == "27.3.A.21","Area"] <- "27.3.A"
rectangles[rectangles$Area == "27.3.B.23","Area"] <- "27.3.B"
rectangles[rectangles$Area == "27.3.C.22","Area"] <- "27.3.C"

isa12[isa12$Area == "27.3.A.20","Area"] <- "27.3.A"
isa12[isa12$Area == "27.3.A.21","Area"] <- "27.3.A"
isa12[isa12$Area == "27.3.B.23","Area"] <- "27.3.B"
isa12[isa12$Area == "27.3.C.22","Area"] <- "27.3.C"

sframe[sframe$Area == "27.3.20","Area"] <- "27.3.A"
sframe[sframe$Area == "27.3.21","Area"] <- "27.3.A"
sframe[sframe$Area == "27.3.23","Area"] <- "27.3.B"
sframe[sframe$Area == "27.3.22","Area"] <- "27.3.C"

# Check: shouldn't have any 24.x.x areas
# Areas in ICES assessment but missing in rectangles
### rewrite
unique(isa12$Area)[!(unique(isa12$Area) %in% unique(rectangles$Area))]
#[1] "21.1" "21.2"

# Areas in FMZ but missing in rectangles
unique(sframe$Area)[!(unique(sframe$Area) %in% unique(rectangles$Area))]
#[1] "21.1.F"  "21.3.M"  "34.1.2"  "34.1.13" "34.1.11" "34.1.12" "34.2"

#------------------------------------------------------------------
# fix species codes
#------------------------------------------------------------------
#check the species code
# Horse mackerel
# Checked in 2019 and HOM still exists
isa12[isa12$Species=="HOM","Species"] <- "JAX"
# ANK & MON - Anglerfish - species to genus
# Checked in 2019 and ANK+MON still exist
isa12[isa12$Species=="ANK","Species"] <- "ANF"
isa12[isa12$Species=="MON","Species"] <- "ANF"
# Megrim - species and genus to genus
# Checked in 2019 and MEG+LDB still exist
isa12[isa12$Species=="MEG","Species"] <- "LEZ"
isa12[isa12$Species=="LDB","Species"] <- "LEZ"
# species with combined TACs (NOTE THESE CAN INCREASE IN THE FUTURE)
# WIT there's a combined TAC with lemon sole: L/W/2AC4-C
# TUR there's a combined TAC with brill T/B/2AC4-C
# Both TUR and WIT were not cat 1 in 2017 assessments
isa12[isa12$Species=="WIT","Species"] <- "L/W"
isa12[isa12$Species=="TUR","Species"] <- "T/B"
# missing species
sort(unique(isa12$Species)[!(unique(isa12$Species) %in% unique(sframe$Species))])
```

```
#[1] "BSS" "PIL" "REB"
# REB is in areas outside EU waters 27.5, 27.12, 27.14
# PIL and BSS don't have TACs

#-------------------------------------------------------------------
# merge assessments,tacs/sf and rectangles
#-------------------------------------------------------------------

# merge assessments with rectangles
isa12r <- merge(isa12, rectangles[,c("Area","Rectangle")], by="Area")

# Do we have all the assessments?
all(sort(unique(isa12$FishStock)) == sort(unique(isa12r$FishStock)))

# Merge sampling frame with rectangles
sfr <- merge(sframe, rectangles[,c("Area","Rectangle")], by="Area")

# Do we have all the TACs?
all(sort(unique(sframe$TAC_id)) == sort(unique(sfr$TAC_id)))

# merge assessments with sampling frame
isa12sf <- merge(sfr, isa12r[,c("Species","Rectangle","FishStock","DataCategory")], by=c("Species","Rectangle"), all.x = TRUE)

#-------------------------------------------------------------------
# final stock list
#-------------------------------------------------------------------

# remove stocks with short time series
sts <- subset(isa, Year %in% dy & !is.na(FishingPressure))$FishStock
# remove short time series
sts <- table(sts)
sts <- names(sts)[sts<5]
# remove also nep.fu.3-4, assessment area is not stable so doesn't have 5 years of comparable data
sts <- c(sts, "nep.fu.3-4")

# stocks to retain
stkToRetain <- unique(isa12sf$FishStock)[-1]
stkToRetain <- stkToRetain[!(stkToRetain %in% sts)]

#-------------------------------------------------------------------
# subset assessments
#-------------------------------------------------------------------
# filtering
saeu <- subset(isa, FishStock %in% stkToRetain)

# reporting
stkToDrop <- unique(isa[!(isa$FishStock %in% stkToRetain), c("FishStock", "EcoRegion", "DataCategory")])
write.csv(stkToDrop, file="stkToDropBySampFrame-nea.csv")
stkToRetain <- unique(isa[isa$FishStock %in% stkToRetain, c("FishStock", "EcoRegion", "DataCategory")])
write.csv(stkToRetain, file="stkToRetainBySampFrame-nea.csv")

# check what's available
table(saeu[,c("FishingPressureDescription","StockSizeDescription")])

#===================================================================
# process data for indicators
#===================================================================

#-------------------------------------------------------------------
# fixing BMSYescapment not reported by ICES
#-------------------------------------------------------------------
saeu$MSYBescapement <- NA

# NOP 34
saeu[saeu$FishStock == "nop.27.3a4", c("StockSize", "MSYBescapement")] <- saeu[saeu$FishStock == "nop.27.3a4", c("Low_StockSize", "Blim")]

# ANE BISC - need to add value from ss, using upper trigger as proxy for MSYBescapement
saeu[saeu$FishStock == "ane.27.8", "MSYBescapement"] <- 89000

# acording to the sumsheets SAN and SPR-NSEA use Bpa for MSYBescapement
saeu[saeu$FishStock %in% c("san.sa.1r","san.sa.2r","san.sa.3r","san.sa.4","spr.27.3a4"),"MSYBescapement"] <- saeu[saeu$FishStock %in% c("san.sa.1r","san.sa.2r","san.sa.3r","san.sa.4","spr.27.3a4"),"Bpa"]
```

```
#-------------------------------------------------------------------
# fixing Recruitments of 0
#-------------------------------------------------------------------
saeu[saeu$Recruitment==0 & !is.na(saeu$Recruitment),"Recruitment"] <- NA

#-------------------------------------------------------------------
# Bref
#-------------------------------------------------------------------
# check MSYBtrigger approx. Bpa, need some boundaries for rounding
stksBpaMSYBtrigger <- unique(saeu[saeu$MSYBtrigger/saeu$Bpa < 1.05 & saeu$MSYBtrigger/
saeu$Bpa > 0.95, c("FishStock", "Bpa", "MSYBtrigger")])
stksBpaMSYBtrigger <- stksBpaMSYBtrigger[order(stksBpaMSYBtrigger$FishStock),]
write.csv(stksBpaMSYBtrigger, file="stksBpaMSYBtrigger.csv")

# create field
saeu$Bref <- saeu$MSYBtrigger
# if MSYBtrigger is set at Bpa level set to NA, with the exception
# of a couple of stocks which were explicitly set that way by the AWG
saeu$Bref[saeu$MSYBtrigger==saeu$Bpa & !(saeu$FishStock %in% c("hom.27.9a", "pra.
27.3a4a", "sol.27.7e"))] <- NA

# B escapement as Bref for relevant stocks
saeu$Bref[!is.na(saeu$MSYBescapement)] <- saeu$MSYBescapement[!
is.na(saeu$MSYBescapement)]
saeu$Bref <- as.numeric(saeu$Bref)
# set 0 as NA
saeu$Bref[saeu$Bref==0] <- NA
# if relative Bref = 1
saeu[saeu$StockSizeDescription == "B/Bmsy", "Bref"] <- 1

# Bpa
saeu$Brefpa <- saeu$Bpa
# some stocks don't have Bpa (it was set at MSYBtrigger level)
saeu$Brefpa[saeu$FishStock %in% c("hom.27.9a")] <- NA
# set 0 as NA
saeu$Brefpa[saeu$Brefpa==0] <- NA
# if relative Brefpa = 0.5
saeu[saeu$StockSizeDescription == "B/Bmsy", "Brefpa"] <- 0.5

#-------------------------------------------------------------------
# Fref
#-------------------------------------------------------------------
saeu$Fref <- saeu$FMSY
# no Fref for B escapement
saeu$Fref[!is.na(saeu$MSYBescapement)] <- NA
saeu$Fref <- as.numeric(saeu$Fref)
# set 0 as NA
saeu$Fref[saeu$Fref==0] <- NA
# if relative Fmsy must be 1
saeu[saeu$FishingPressureDescription %in% c("F/Fmsy", "HR/HRmsy"), "Fref"] <- 1

saeu$Frefpa <- saeu$Fpa
# no Fref for B escapement
saeu$Frefpa[!is.na(saeu$MSYBescapement)] <- NA
saeu$Frefpa <- as.numeric(saeu$Frefpa)
# set 0 as NA
saeu$Frefpa[saeu$Frefpa==0] <- NA
# if relative Fparef must be NA
saeu[saeu$FishingPressureDescription %in% c("F/Fmsy", "HR/HRmsy"), "Frefpa"] <- NA

#-------------------------------------------------------------------
# COMPUTE F/Fref and B/Bref | year + stock
#-------------------------------------------------------------------
saeu <- transform(saeu,
    indF = FishingPressure/Fref,
    indB=StockSize/Bref,
    indBpa=StockSize/Brefpa,
    indFpa = FishingPressure/Frefpa)

# in case of escapement strategy MSY evaluated by SSB ~ Bref
saeu$indF[!is.na(saeu$MSYBescapement)] <-
    saeu$Bref[!is.na(saeu$MSYBescapement)]/saeu$StockSize[!is.na(saeu$MSYBescapement)]

saeu <- transform(saeu, sfFind=!is.na(indF))

#-------------------------------------------------------------------
# COMPUTE SBL | year + FishStock
```

```r
#--------------------------------------------------------------------
saeu$SBL <- !(saeu$indFpa > 1 | saeu$indBpa < 1)
# if one is NA SBL can't be inferred
saeu$SBL[is.na(saeu$indFpa) | is.na(saeu$indBpa)] <- NA
# no SBL for B escapement
saeu$SBL[!is.na(saeu$MSYBescapement)] <- NA
saeu <- transform(saeu, sfSBL=!is.na(SBL))

#--------------------------------------------------------------------
# COMPUTE CFP objectives | year + FishStock
#--------------------------------------------------------------------
saeu$CFP <- !(saeu$indF > 1 | saeu$indB < 1)
# if one is NA CFP can't be inferred
saeu$CFP[is.na(saeu$indF) | is.na(saeu$indB)] <- NA
# no CFP for B escapement
saeu$CFP[!is.na(saeu$MSYBescapement)] <- NA
saeu <- transform(saeu, sfCFP=!is.na(CFP))

#--------------------------------------------------------------------
# final dataset
#--------------------------------------------------------------------
# remove WG projections
saeu <- saeu0 <- subset(saeu, Year <= fnlYear)
saeu <- subset(saeu, Year>=iniYear & assessmentYear %in% vay & sfFind)

#--------------------------------------------------------------------
# project stock status up to last year in cases missing
#--------------------------------------------------------------------

saeu <- projectStkStatus(saeu, vpy)

moo1 <- saeu[!saeu$projected, c("FishStock", "Year", "EcoRegion")]
moo2 <- table(moo1[,c("FishStock", "Year", "EcoRegion")])
moo2 <- dcast(data.frame(moo2), FishStock~Year, value.var = 'Freq' )
#====================================================================
# Indicators (design based)
#====================================================================

#--------------------------------------------------------------------
# Number of stocks (remove projected years)
#--------------------------------------------------------------------
df0 <- saeu[!saeu$projected,]
inStks <- getNoStks(df0, "FishStock", length)

# check for potential duplicates
mo1 <- df0[df0$EcoRegion == "Greater North Sea", c("EcoRegion", "FishStock", "Year")]
table(mo1[,c("FishStock", "Year")])

png("figNEAI0a.png", 1800, 1200, res=300)
ggplot(subset(inStks, EcoRegion=="ALL"), aes(x=Year, y=N)) +
    geom_line() +
    ylab("No. of stocks") +
    xlab("") +
    ylim(c(0,80)) +
    sc +
    th
dev.off()

# time series
# check stocks with non continuos time series
# plot needs to be fixed mannualy but should be possible to auto
stks_ncts <- tapply(df0$Year, df0$FishStock, function(x){
    !(max(x) - min(x) + 1 == length(x))
})
stks_ncts <- names(stks_ncts)[stks_ncts]

png("figNEAI0b.png", 3000, 4500, res=300, bg = "transparent")
ggplot(df0, aes(Year, reorder(FishStock, desc(FishStock)))) +
    geom_line() +
    geom_point(data=aggregate(list(Year=df0$Year, EcoRegion=df0$EcoRegion),
        by=list(FishStock=df0$FishStock), max)) +
  # NEP missing years
    geom_line(data=data.frame(Year=2009:2013, FishStock="nep.fu.14",
    EcoRegion="Celtic Seas"), color="white") +
    geom_line(data=data.frame(Year=2007:2009, FishStock="nep.fu.13",
    EcoRegion="Celtic Seas"), color="white") +
    geom_line(data=data.frame(Year=2003:2005, FishStock="nep.fu.13",
    EcoRegion="Celtic Seas"), color="white") +
```

```
    geom_point(data=data.frame(Year=2003, FishStock="nep.fu.13",
    EcoRegion="Celtic Seas"), size=0.3) +
    ylab("") +
    xlab("Year") +
    sc +
    th +
    facet_grid(EcoRegion~., switch="y", space="free_y", scales="free_y") +
    theme(strip.placement="outside", strip.background.y=element_blank(),
    panel.spacing.y=unit(0.05, "lines"))
dev.off()

write.csv(dcast(inStks, EcoRegion~Year, value.var='N'), file="tabNEAI0.csv",
row.names=FALSE)

#------------------------------------------------------------------
# (I1) Stocks F > Fmsy
#------------------------------------------------------------------
fInda <- getNoStks(saeu, "indF", function(x) sum(x>1))

# plot
png("figNEAI1.png", 1800, 1200, res=300)
ggplot(subset(fInda, EcoRegion=='ALL'), aes(x=Year, y=N)) +
    geom_line() +
    expand_limits(y=0) +
    geom_point(aes(x=iniYear, y=N[1])) +
    geom_point(aes(x=fnlYear, y=N[length(N)]), size=2) +
    ylab("No. of stocks") +
    xlab("") +
    ylim(c(0,75)) +
    sc +
    th
dev.off()

# plot
png("figNEAI1b.png", 2400, 1200, res=300)
ggplot(subset(fInda, EcoRegion != 'ALL'), aes(x=Year, y=N)) +
    geom_line() +
    facet_grid(.~EcoRegion) +
    ylab("No. of stocks") +
    xlab("") +
    sc +
    ylim(0, 20) +
    th
dev.off()

# table
write.csv(dcast(fInda, EcoRegion~Year, value.var='N'), file="tabNEAI1.csv",
row.names=FALSE)

#------------------------------------------------------------------
# (I2) Stocks F <= Fmsy
#------------------------------------------------------------------
fIndb <- getNoStks(saeu, "indF", function(x) sum(x<=1))

# plot
png("figNEAI2.png", 1800, 1200, res=300)
ggplot(subset(fIndb, EcoRegion=='ALL'), aes(x=Year, y=N)) +
    geom_line() +
    expand_limits(y=0) +
    geom_point(aes(x=iniYear, y=N[1])) +
    geom_point(aes(x=fnlYear, y=N[length(N)]), size=2) +
    ylab("No. of stocks") +
    xlab("") +
    ylim(c(0,75)) +
    sc +
    th
dev.off()

# plot
png("figNEAI2b.png", 2400, 1200, res=300)
ggplot(subset(fIndb, EcoRegion != 'ALL'), aes(x=Year, y=N)) +
    geom_line() +
    facet_grid(.~EcoRegion) +
    ylab("No. of stocks") +
    xlab("") +
    sc +
    ylim(0, 20) +
    th
```

```
dev.off()

# table
write.csv(dcast(fIndb, EcoRegion~Year, value.var='N'), file="tabNEAI2.csv",
row.names=FALSE)

#-------------------------------------------------------------------
# (I3) Stocks outside SBL
#-------------------------------------------------------------------
fIndc <- getNoStks(saeu, "SBL", function(x) sum(!x, na.rm=TRUE))

# plot
png("figNEAI3.png", 1800, 1200, res=300)
ggplot(subset(fIndc, EcoRegion=='ALL'), aes(x=Year, y=N)) +
    geom_line() +
    expand_limits(y=0) +
    geom_point(aes(x=iniYear, y=N[1])) +
    geom_point(aes(x=fnlYear, y=N[length(N)]), size=2) +
    ylab("No. of stocks") +
    xlab("") +
    ylim(c(0,75)) +
    sc +
    th
dev.off()

# plot
png("figNEAI3b.png", 2400, 1200, res=300)
ggplot(subset(fIndc, EcoRegion != 'ALL'), aes(x=Year, y=N)) +
    geom_line() +
    facet_grid(.~EcoRegion) +
    ylab("No. of stocks") +
    xlab("") +
    sc +
    ylim(0, 15) +
    th
dev.off()

# table
write.csv(dcast(fIndc, EcoRegion~Year, value.var='N'), file="tabNEAI3.csv",
row.names=FALSE)

#-------------------------------------------------------------------
# (I4) Stocks inside SBL
#-------------------------------------------------------------------
fIndd <- getNoStks(saeu, "SBL", function(x) sum(x, na.rm=TRUE))

## plot
png("figNEAI4.png", 1800, 1200, res=300)
ggplot(subset(fIndd, EcoRegion=='ALL'), aes(x=Year, y=N)) +
    geom_line() +
    expand_limits(y=0) +
    geom_point(aes(x=iniYear, y=N[1])) +
    geom_point(aes(x=fnlYear, y=N[length(N)]), size=2) +
    ylab("No. of stocks") +
    xlab("") +
    ylim(c(0,75)) +
    sc +
    th
dev.off()

# plot
png("figNEAI4b.png", 2400, 1200, res=300)
ggplot(subset(fIndd, EcoRegion != 'ALL'), aes(x=Year, y=N)) +
    geom_line() +
    facet_grid(.~EcoRegion) +
    ylab("No. of stocks") +
    xlab("") +
    sc +
    ylim(0, 15) +
    th
dev.off()

# table
write.csv(dcast(fIndd, EcoRegion~Year, value.var='N'), file="tabNEAI4.csv",
row.names=FALSE)

#-------------------------------------------------------------------
# (I5) Stocks outside CFP objectives
```

```
#-------------------------------------------------------------------
fIndf <- getNoStks(saeu, "CFP", function(x) sum(!x, na.rm=TRUE))

## plot
png("figNEAI5.png", 1800, 1200, res=300)
ggplot(subset(fIndf, EcoRegion=='ALL'), aes(x=Year, y=N)) +
    geom_line() +
    expand_limits(y=0) +
    geom_point(aes(x=iniYear, y=N[1])) +
    geom_point(aes(x=fnlYear, y=N[length(N)]), size=2) +
    ylab("No. of stocks") +
    xlab("") +
    ylim(c(0,75)) +
    sc +
    th
dev.off()

# plot
png("figNEAI5b.png", 2400, 1200, res=300)
ggplot(subset(fIndf, EcoRegion != 'ALL'), aes(x=Year, y=N)) +
    geom_line() +
    facet_grid(.~EcoRegion) +
    ylab("No. of stocks") +
    xlab("") +
    sc +
    ylim(0, 20) +
    th
dev.off()

# table
write.csv(dcast(fIndf, EcoRegion~Year, value.var='N'), file="tabNEAI5.csv",
row.names=FALSE)

#-------------------------------------------------------------------
# (I6) Stocks inside CFP objectives
#-------------------------------------------------------------------
fIndfb <- getNoStks(saeu, "CFP", function(x) sum(x, na.rm=TRUE))

# plot
png("figNEAI6.png", 1800, 1200, res=300)
ggplot(subset(fIndfb, EcoRegion=='ALL'), aes(x=Year, y=N)) +
    geom_line() +
    expand_limits(y=0) +
    geom_point(aes(x=iniYear, y=N[1])) +
    geom_point(aes(x=fnlYear, y=N[length(N)]), size=2) +
    ylab("No. of stocks") +
    xlab("") +
    ylim(c(0,75)) +
    sc +
    th
dev.off()

# plot
png("figNEAI6b.png", 2400, 1200, res=300)
ggplot(subset(fIndfb, EcoRegion != 'ALL'), aes(x=Year, y=N)) +
    geom_line() +
    facet_grid(.~EcoRegion) +
    ylab("No. of stocks") +
    xlab("") +
    sc +
    ylim(0, 20) +
    th
dev.off()

# table
write.csv(dcast(fIndfb, EcoRegion~Year, value.var='N'), file="tabNEAI6.csv",
row.names=FALSE)

#===================================================================
# Indicators (model based)
#===================================================================

#-------------------------------------------------------------------
# (I7) F/Fmsy model
#-------------------------------------------------------------------
idx <- saeu$FishingPressureDescription %in% c("F", "F/Fmsy")
saeu$sfI7 <- idx & is.na(saeu$MSYBescapement)
df0 <- saeu[saeu$sfI7,]
```

```r
df0$Year <- factor(df0$Year)
yrs <- levels(df0$Year)
nd <- data.frame(Year=factor(yrs))

# fit
ifit <- glmer(indF ~ Year + (1|FishStock), data = df0, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
runDiagsME(ifit, "FishStock", df0, "diagNEAI7.pdf", nc, nd)

# bootstrap
stk <- unique(df0$FishStock)
ifit.bs <- split(1:it, 1:it)

ifit.bs <- mclapply(ifit.bs, function(x){
    stk <- sample(stk, replace=TRUE)
    df1 <- df0[0,]
    for(i in stk) df1 <- rbind(df1, subset(df0, FishStock==i))
    fit <- glmer(indF ~ Year + (1|FishStock), data = df1, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
    v0 <- predict(fit, re.form=~0, type="response", newdata=nd)
    if(length(fit@optinfo$conv$lme4)>0) v0[] <- NA
    v0
}, mc.cores=nc)

ifitm <- do.call("rbind", ifit.bs)
ifitq <- apply(ifitm, 2, quantile, qtl, na.rm=TRUE)
ifitq <- cbind(Year=as.numeric(yrs), as.data.frame(t(ifitq)))

# plot
png("figNEAI7.png", 1800, 1200, res=300)
ggplot(ifitq, aes(x=Year)) +
  geom_ribbon(aes(ymin = `2.5%`, ymax = `97.5%`), fill="gray", alpha=0.60) +
  geom_ribbon(aes(ymin = `25%`, ymax = `75%`), fill="gray", alpha=0.95) +
  geom_line(aes(y=`50%`)) + expand_limits(y=0) +
  geom_point(aes(x=Year[1], y=`50%`[1])) +
  geom_point(aes(x=Year[length(Year)], y=`50%`[length(`50%`)]), size=2) +
  geom_hline(yintercept = 1, linetype=2) +
  ylab(expression(F/F[MSY])) +
  ylim(0, 2.5) +
  xlab("") +
  theme(legend.position = "none") +
  sc +
  th
dev.off()

# table
tb0 <- t(ifitq)[-1,]
colnames(tb0) <- ifitq[,1]
write.csv(tb0, file="tabNEAI7.csv")

#------------------------------------------------------------------
# (I7b) F/Fmsy model regional
#------------------------------------------------------------------
df0 <- saeu[saeu$sfI7,]
df0$Year <- factor(df0$Year)
yrs <- levels(df0$Year)
nd <- data.frame(Year=factor(yrs))

ifitRegional <- lapply(split(df0, df0$EcoRegion), function(x){
    # fit model
    ifit <- glmer(indF ~ Year + (1|FishStock), data = x, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
    # no variance with bootstrap due to small number of stocks
    ifit.pred <- predict(ifit, re.form=~0, type="response", newdata=nd)
    # output
    list(ifit=ifit, ifit.pred=ifit.pred)
})

# naming including No of stocks
No <- lapply(split(df0, df0$EcoRegion), function(x) length(unique(x$FishStock)))
names(ifitRegional) <- paste(names(No), " (", No, ")", sep="")

lst0 <- lapply(ifitRegional, "[[", "ifit.pred")
fIndfr <- data.frame(EcoRegion=rep(names(lst0), lapply(lst0, length)), N=unlist(lst0),
Year=as.numeric(as.character(nd[,1])))

# plot
png("figNEAI7b.png", 2400, 1200, res=300)
```

```
ggplot(fIndfr, aes(x=Year, y=N)) +
    geom_line() +
    facet_grid(.~EcoRegion) +
    ylab(expression(F/F[MSY])) +
    xlab("") +
    sc +
    ylim(0, 2.5) +
    th
dev.off()

# table
write.csv(dcast(fIndfr, EcoRegion~Year, value.var='N'), file="tabNEAI7b.csv",
row.names=FALSE)

#------------------------------------------------------------------
# (I7out) F/Fmsy stocks outside EU
#------------------------------------------------------------------
df0 <- subset(isa, (EcoRegion %in% c("Arctic Ocean", "Greenland Sea", "Faroes",
"Iceland Sea") | FishStock=="her.27.1-24a514a") & FishStock!="pra.27.1-2" &
Year>=iniYear & Year<=fnlYear & AssessmentYear %in% vay)
df0$Fref <- as.numeric(df0$FMSY)
df0 <- transform(df0, indF = FishingPressure/Fref, sfFind=!is.na(FishingPressure/Fref))
idx <- df0$FishingPressureDescription %in% c("F", "F/Fmsy") & df0$sfFind
df0 <- df0[idx,]

# check data series is complete
table(df0[,c("FishStock","Year")])

# create year variable for prediction
df0$Year <- factor(df0$Year)
yrs <- levels(df0$Year)
nd <- data.frame(Year=factor(yrs))

# fit
ifitout <- glmer(indF ~ Year + (1|FishStock), data = df0, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
runDiagsME(ifitout, "FishStock", df0, "diagNEAI7out.pdf", nc, nd)

# bootstrap
stk <- unique(df0$FishStock)
ifitout.bs <- split(1:it, 1:it)
ifitout.bs <- mclapply(ifitout.bs, function(x){
    stk <- sample(stk, replace=TRUE)
    df1 <- df0[0,]
    for(i in stk) df1 <- rbind(df1, subset(df0, FishStock==i))
    fit <- glmer(indF ~ Year + (1|FishStock), data = df1, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
    v0 <- predict(fit, re.form=~0, type="response", newdata=nd)
    if(length(fit@optinfo$conv$lme4)>0) v0[] <- NA
    v0
}, mc.cores=nc)

ifitm <- do.call("rbind", ifitout.bs)
ifitq <- apply(ifitm, 2, quantile, qtl, na.rm=TRUE)
ifitq <- cbind(Year=as.numeric(yrs), as.data.frame(t(ifitq)))

# plot
png("figNEAI7out.png", 1800, 1200, res=300)
ggplot(ifitq, aes(x=Year)) +
  geom_ribbon(aes(ymin = `2.5%`, ymax = `97.5%`), fill="gray", alpha=0.60) +
  geom_ribbon(aes(ymin = `25%`, ymax = `75%`), fill="gray", alpha=0.95) +
  geom_line(aes(y=`50%`)) + expand_limits(y=0) +
  geom_point(aes(x=Year[1], y=`50%`[1])) +
  geom_point(aes(x=Year[length(Year)], y=`50%`[length(`50%`)]), size=2) +
  ylab(expression(F/F[MSY])) +
  geom_hline(yintercept = 1, linetype=2) +
  ylim(0, 2.5) +
  xlab("") +
  theme(legend.position = "none") +
  sc +
  th
dev.off()

# table
tb0 <- t(ifitq)[-1,]
colnames(tb0) <- ifitq[,1]
write.csv(tb0, file="tabNEAI7out.csv")
```

```
#-------------------------------------------------------------------
# (I8) SSB model
#-------------------------------------------------------------------
saeu$sfI8 <- saeu$StockSizeDescription %in% c("SSB", "TSB")
df0 <- saeu[saeu$sfI8,]
df0$Year <- factor(df0$Year)
yrs <- levels(df0$Year)
nd <- data.frame(Year=factor(yrs))

# fit
ifitb <- glmer(StockSize ~ Year + (1|FishStock), data =  df0, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
runDiagsME(ifitb, "FishStock", df0, "diagNEAI8.pdf", nc, nd)

# bootstrap
stk <- unique(df0$FishStock)
ifitb.bs <- split(1:it, 1:it)
ifitb.bs <- mclapply(ifitb.bs, function(x){
    stk <- sample(stk, replace=TRUE)
    df1 <- df0[0,]
    for(i in stk) df1 <- rbind(df1, subset(df0, FishStock==i))
    fit <- glmer(StockSize ~ Year + (1|FishStock), data = df1, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
    v0 <- predict(fit, re.form=~0, type="response", newdata=nd)
    if(length(fit@optinfo$conv$lme4)>0) v0[] <- NA
    v0
}, mc.cores=nc)

ifitm <- do.call("rbind", ifitb.bs)
ifitm <- exp(log(ifitm)-median(log(ifitm[,1]), na.rm=TRUE))
ifitq <- apply(ifitm, 2, quantile, qtl, na.rm=TRUE)
ifitq <- cbind(Year=as.numeric(yrs), as.data.frame(t(ifitq)))

# plot
png("figNEAI8.png", 1800, 1200, res=300)
ggplot(ifitq, aes(x=Year)) +
  geom_ribbon(aes(ymin = `2.5%`, ymax = `97.5%`), fill="gray", alpha=0.60) +
  geom_ribbon(aes(ymin = `25%`, ymax = `75%`), fill="gray", alpha=0.95) +
  geom_line(aes(y=`50%`)) +
  expand_limits(y=0) +
  geom_point(aes(x=Year[1], y=`50%`[1])) +
  geom_point(aes(x=Year[length(Year)], y=`50%`[length(`50%`)]), size=2) +
  geom_hline(yintercept = 1, linetype=2) +
  ylab(expression(B/B[2003])) +
  xlab("") +
  theme(legend.position = "none") +
  sc +
  th
dev.off()

# table
tb0 <- t(ifitq)[-1,]
colnames(tb0) <- ifitq[,1]
write.csv(tb0, file="tabNEAI8.csv")

#-------------------------------------------------------------------
# (I8b) SSB model regional
#-------------------------------------------------------------------
df0 <- saeu[saeu$sfI8,]
df0$Year <- factor(df0$Year)
yrs <- levels(df0$Year)
nd <- data.frame(Year=factor(yrs))

ifitbRegional <- lapply(split(df0, df0$EcoRegion), function(x){
    # fit model
    ifitb <- glmer(StockSize ~ Year + (1|FishStock), data = x, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
    # no variance with bootstrap due to small number of stocks
    ifitb.pred <- predict(ifitb, re.form=~0, type="response", newdata=nd)
    # output
    list(ifitb=ifitb, ifitb.pred=ifitb.pred/ifitb.pred[nd==iniYear])
})

# naming including No of stocks
No <- lapply(split(df0, df0$EcoRegion), function(x) length(unique(x$FishStock)))
names(ifitbRegional) <- paste(names(No), " (", No, ")", sep="")

lst0 <- lapply(ifitbRegional, "[[", "ifitb.pred")
```

```r
fIndbr <- data.frame(EcoRegion=rep(names(lst0), lapply(lst0, length)), N=unlist(lst0),
Year=as.numeric(as.character(nd[,1])))

# plot
png("figNEAI8b.png", 2400, 1200, res=300)
ggplot(fIndbr, aes(x=Year, y=N)) +
    geom_line() +
    facet_grid(.~EcoRegion) +
    geom_hline(yintercept = 1, linetype=2) +
    ylab(expression(B/B[2003])) +
    xlab("") +
    theme(legend.position = "none") +
    sc +
    th
dev.off()

# table
write.csv(dcast(fIndbr, EcoRegion~Year, value.var='N'), file="tabNEAI8b.csv",
row.names=FALSE)

#--------------------------------------------------------------------
# (I10) Recruitment model
#--------------------------------------------------------------------
saeu0$sfI10 <- !is.na(saeu0$Recruitment)
df0 <- saeu0[saeu0$sfI10,]
# data for table about stocks and inicators
sfI10 <- subset(df0, Year>=iniYear & Year<=fnlYear)
sfI10 <- tapply(sfI10$Year, sfI10$FishStock, max)
sfI10 <- data.frame(FishStock=names(sfI10), Year=sfI10, variable="sfI10", value=TRUE)
# project and compute indicator
df0 <- projectStkStatus(df0, vpy)
for(i in (iniYear):fnlYear) df0 <- decadalR(df0, i)
df0 <- subset(df0, Year>=iniYear & Year<=fnlYear)
df0$Year <- factor(df0$Year)
yrs <- levels(df0$Year)
nd <- data.frame(Year=factor(yrs))

# fit
ifitr <- glmer(decadalR ~ Year + (1|FishStock), data =  df0, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
runDiagsME(ifitr, "FishStock", df0, "diagNEAI10.pdf", nc, nd)


# bootstrap
stk <- unique(df0$FishStock)
ifitr.bs <- split(1:it, 1:it)
ifitr.bs <- mclapply(ifitr.bs, function(x){
    stk <- sample(stk, replace=TRUE)
    df1 <- df0[0,]
    for(i in stk) df1 <- rbind(df1, subset(df0, FishStock==i))
    fit <- glmer(decadalR ~ Year + (1|FishStock), data = df1, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
    v0 <- predict(fit, re.form=~0, type="response", newdata=nd)
    if(length(fit@optinfo$conv$lme4)>0) v0[] <- NA
    v0
}, mc.cores=nc)

ifitm <- do.call("rbind", ifitr.bs)
ifitm <- exp(log(ifitm)-median(log(ifitm[,1]), na.rm=TRUE))
ifitq <- apply(ifitm, 2, quantile, qtl, na.rm=TRUE)
ifitq <- cbind(Year=as.numeric(yrs), as.data.frame(t(ifitq)))

# plot
png("figNEAI10.png", 1800, 1200, res=300)
ggplot(ifitq, aes(x=Year)) +
  geom_ribbon(aes(ymin = `2.5%`, ymax = `97.5%`), fill="gray", alpha=0.60) +
  geom_ribbon(aes(ymin = `25%`, ymax = `75%`), fill="gray", alpha=0.95) +
  geom_line(aes(y=`50%`)) +
  expand_limits(y=0) +
  geom_point(aes(x=Year[1], y=`50%`[1])) +
  geom_point(aes(x=Year[length(Year)], y=`50%`[length(`50%`)]), size=2) +
  geom_hline(yintercept = 1, linetype=2) +
  #ylab(expression(decadal_R/R[2003])) +
  ylab("Decadal recruitment (scaled to 2003)") +
  xlab("") +
  theme(legend.position = "none") +
  sc +
  th
dev.off()
```

```
# table
tb0 <- t(ifitq)[-1,]
colnames(tb0) <- ifitq[,1]
write.csv(tb0, file="tabNEAI10.csv")

#--------------------------------------------------------------------
# (I10b) R model regional
#--------------------------------------------------------------------

ifitrRegional <- lapply(split(df0, df0$EcoRegion), function(x){
    # fit model
    ifitr <- glmer(decadalR ~ Year + (1|FishStock), data = x, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
    # no variance with bootstrap due to small number of stocks
    ifitr.pred <- predict(ifitr, re.form=~0, type="response", newdata=nd)
    # output
    list(ifitr=ifitr, ifitr.pred=ifitr.pred/ifitr.pred[nd==iniYear])
})

# naming including No of stocks
No <- lapply(split(df0, df0$EcoRegion), function(x) length(unique(x$FishStock)))
names(ifitrRegional) <- paste(names(No), " (", No, ")", sep="")

lst0 <- lapply(ifitrRegional, "[[", "ifitr.pred")
fIndrr <- data.frame(EcoRegion=rep(names(lst0), lapply(lst0, length)), N=unlist(lst0),
Year=as.numeric(as.character(nd[,1])))

# plot
png("figNEAI10b.png", 2400, 1200, res=300)
ggplot(fIndrr, aes(x=Year, y=N)) +
    geom_line() +
    facet_grid(.~EcoRegion) +
    geom_hline(yintercept = 1, linetype=2) +
    ylab("Decadal recruitment (scaled to 2003)") +
    xlab("") +
    theme(legend.position = "none") +
    sc +
    th
dev.off()

# table
write.csv(dcast(fIndrr, EcoRegion~Year, value.var='N'), file="tabNEAI10b.csv",
row.names=FALSE)

#--------------------------------------------------------------------
# (I12) SSB model for cat 3
# >>> Check which are in sampling frame
# >>> Add to report Abundance indices also used
#--------------------------------------------------------------------

df0 <- subset(isa, !(EcoRegion %in% c("Arctic Ocean", "Greenland Sea", "Faroes",
"Iceland Sea")) & DataCategory>2 & DataCategory<4 & StockSize>0 &  Year>=iniYear & Year
<= fnlYear & AssessmentYear %in% vay & StockSizeDescription %in% c("Biomass index",
"Abundance index", "SSB", "TSB", "Relative BI (comb)", "B/Bmsy", "Relative SSB",
"standardized CPUE", "Relative BI", "Biomass Index (comb)", "LPUE"))

# remove stocks with short time series
sts <- table(df0$FishStock, df0$Year)
sts <- rownames(sts)[apply(sts, 1, sum)<5]
df0 <- subset(df0, !(FishStock %in% sts))

# id
sfI12 <- tapply(df0$Year, df0$FishStock, max)
sfI12 <- data.frame(FishStock=names(sfI12), Year=sfI12, variable="sfI12", value=TRUE)

# project for stocks without 2015, 2016 estimates
# NEED CHECK
df0 <- projectStkStatus(df0, vpy)

# pre process for model
df0$Year <- factor(df0$Year)
yrs <- levels(df0$Year)
nd <- data.frame(Year=factor(yrs))

# fit
ifitb3 <- glmer(StockSize ~ Year + (1|FishStock), data =  df0, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
```

```
runDiagsME(ifitb3, "FishStock", df0, "diagNEAI12.pdf", nc, nd)

# bootstrap
stk <- unique(df0$FishStock)
ifitb3.bs <- split(1:it, 1:it)
ifitb3.bs <- mclapply(ifitb3.bs, function(x){
    stk <- sample(stk, replace=TRUE)
    df1 <- df0[0,]
    for(i in stk) df1 <- rbind(df1, subset(df0, FishStock==i))
    fit <- glmer(StockSize ~ Year + (1|FishStock), data = df1, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
    v0 <- predict(fit, re.form=~0, type="response", newdata=nd)
    if(length(fit@optinfo$conv$lme4)>0) v0[] <- NA
    v0
}, mc.cores=nc)

ifitm <- do.call("rbind", ifitb3.bs)
ifitm <- exp(log(ifitm)-median(log(ifitm[,1]), na.rm=TRUE))
ifitq <- apply(ifitm, 2, quantile, qtl, na.rm=TRUE)
ifitq <- cbind(Year=as.numeric(yrs), as.data.frame(t(ifitq)))

# plot
png("figNEAI12.png", 1800, 1200, res=300)
ggplot(ifitq, aes(x=Year)) +
  geom_ribbon(aes(ymin = `2.5%`, ymax = `97.5%`), fill="gray", alpha=0.60) +
  geom_ribbon(aes(ymin = `25%`, ymax = `75%`), fill="gray", alpha=0.95) +
  geom_line(aes(y=`50%`)) +
  expand_limits(y=0) +
  geom_point(aes(x=Year[1], y=`50%`[1])) +
  geom_point(aes(x=Year[length(Year)], y=`50%`[length(`50%`)]), size=2) +
  geom_hline(yintercept = 1, linetype=2) +
  ylab(expression(B/B[2003])) +
  xlab("") +
  theme(legend.position = "none") +
  sc +
  th
dev.off()

tb0 <- t(ifitq)[-1,]
colnames(tb0) <- ifitq[,1]
write.csv(tb0, file="tabNEAI12.csv")

#====================================================================
# Bootstrap convergence problems
#====================================================================

bootconv <- data.frame(
    indicator=c('F/Fmsy trends', 'F/Fmsy trends out', 'Biomass trends', 'Decadal
recruitment trends', "Biomass data category 3 trends"),
    convergence=c(sum(unlist(lapply(lapply(ifit.bs, is.na), sum))==0),
sum(unlist(lapply(lapply(ifitout.bs, is.na), sum))==0),
sum(unlist(lapply(lapply(ifitb.bs, is.na), sum))==0),
sum(unlist(lapply(lapply(ifitr.bs, is.na), sum))==0),
sum(unlist(lapply(lapply(ifitb3.bs, is.na), sum))==0))/it
)

write.csv(bootconv, file="bootconv.csv")

#====================================================================
# Stocks used in each indicator
#====================================================================

df0 <- melt(saeu[!saeu$projected,], c('FishStock', 'Year'), c('sfFind', 'sfSBL',
'sfCFP', 'sfI7', 'sfI8'))
df0 <- do.call("rbind", lapply(split(df0, df0$FishStock), function(x) subset(x,
Year==max(x$Year))))
# fix year for I10 when assessment not from previous year
df1 <- sfI10
df1$Year <- subset(df0, FishStock %in% df1$FishStock & variable=="sfFind")$Year
# merge
df0 <- merge(df0, df1, all=TRUE)
df0 <- rbind(df0, sfI12)
levels(df0$variable) <- c('above/below Fmsy', 'in/out SBL', 'in/out CFP', 'F/Fmsy
trends', 'Biomass trends', 'Decadal recruitment trends', "Biomass data category 3
trends")
stkPerIndicator <- dcast(df0, FishStock+Year~variable, value.var='value')

# NOTE: this file must be fixed "by hand" to remove duplications
```

```r
# created for the cat 1 stocks which were projected
# (no time to right code now ...)
write.csv(stkPerIndicator, file="stkPerIndicator.csv")

#===================================================================
# Coverage
#===================================================================

# All stocks of relevance
stocks <- subset(saeu, Year==fnlYear)$FishStock
# All stocks with B indicator
bind_stocks <- subset(saeu, Year==fnlYear & !is.na(indB))$FishStock
# All stocks with F indicator - Same as stocks
find_stocks <- subset(saeu, Year==fnlYear & !is.na(indF))$FishStock
# All stocks with Bpa indicator
bpaind_stocks <- subset(saeu, Year==fnlYear & !is.na(indBpa))$FishStock
# All stocks with Fpa indicator - Same as stocks
fpaind_stocks <- subset(saeu, Year==fnlYear & !is.na(indFpa))$FishStock

# Current list
all_stocks <- unique(isa12sf$FishStock)
# ignore NA
all_stocks <- all_stocks[!is.na(all_stocks)]

# Which stocks to drop from all stocks
drop_stock <- all_stocks[!(all_stocks %in% stocks)]

# Which stocks to drop as no f indicator
drop_stock_f <- all_stocks[!(all_stocks %in% find_stocks)]

# Which stocks to drop as no b indicator
drop_stock_b <- all_stocks[!(all_stocks %in% bind_stocks)]

# Which stocks to drop as no fpa indicator
drop_stock_fpa <- all_stocks[!(all_stocks %in% fpaind_stocks)]

# Which stocks to drop as no bpa indicator
drop_stock_bpa <- all_stocks[!(all_stocks %in% bpaind_stocks)]

# Set dropped stocks to NA in FishStock column
isa12sf$FindFishStock <- isa12sf$FishStock
isa12sf[isa12sf$FindFishStock %in% drop_stock_f,"FindFishStock"] <- as.character(NA)
isa12sf$BindFishStock <- isa12sf$FishStock
isa12sf[isa12sf$BindFishStock %in% drop_stock_b ,"BindFishStock"] <- as.character(NA)
isa12sf$FpaindFishStock <- isa12sf$FishStock
isa12sf[isa12sf$FpaindFishStock %in% drop_stock_fpa,"FpaindFishStock"] <-
as.character(NA)
isa12sf$BpaindFishStock <- isa12sf$FishStock
isa12sf[isa12sf$BpaindFishStock %in% drop_stock_bpa,"BpaindFishStock"] <-
as.character(NA)

# Proportion of TACs that have at least one rectangle assessed by FindFishStock and
BindFishStock
outf <- aggregate(isa12sf$FindFishStock, by=list(isa12sf$TAC_id), function(x) {
          no_rect_ass_find <- sum(!is.na(x))
          assessed_find <- no_rect_ass_find > 1
          return(assessed_find)
})

outb <- aggregate(isa12sf$BindFishStock, by=list(isa12sf$TAC_id), function(x) {
          no_rect_ass_bind <- sum(!is.na(x))
          assessed_bind <- no_rect_ass_bind > 1
          return(assessed_bind)
})

outfpa <- aggregate(isa12sf$FpaindFishStock, by=list(isa12sf$TAC_id), function(x) {
          no_rect_ass_find <- sum(!is.na(x))
          assessed_find <- no_rect_ass_find > 1
          return(assessed_find)
})

outbpa <- aggregate(isa12sf$BpaindFishStock, by=list(isa12sf$TAC_id), function(x) {
          no_rect_ass_bind <- sum(!is.na(x))
          assessed_bind <- no_rect_ass_bind > 1
          return(assessed_bind)
})

coverage <- data.frame(
```

```r
    No_stocks = c(length(find_stocks), length(bind_stocks), length(fpaind_stocks),
length(bpaind_stocks)),
    No_TACs = length(unique(isa12sf$TAC_id)),
    No_TACs_assessed = c(sum(outf$x), sum(outb$x), sum(outfpa$x), sum(outbpa$x)),
    Frac_TACs_assessed = c(mean(outf$x),mean(outb$x), mean(outfpa$x), mean(outbpa$x))
)
rownames(coverage) <- c("F_indicator", "B_indicator", "Fpa_indicator", "Bpa_indicator")

write.csv(coverage, "coverage.csv")

# number of stocks for which MSYBtrigger==Bpa
#df0 <- transform(saeu, bb=Bpa/MSYBtrigger==1)
#length(unique(subset(df0, bb==TRUE)$FishStock))

#====================================================================
# Exporting and saving
#====================================================================

write.csv(saeu, file="saeu.csv")
save.image("RData.nea")
```

12 ANNEX 2B - MED CODE

```r
#####################################################################
# EJ(20190319)
# MED indicators
#####################################################################

library(ggplot2)
library(lme4)
library(influence.ME)
library(lattice)
library(parallel)
library(rgdal)
library(reshape2)
library(plyr)
source("funs.R")

#====================================================================
# Setup
#====================================================================

# year when assessments were performed
assessmentYear <- 2019
# final year with estimations from stock assessments
fnlYear <- assessmentYear - 1
# initial year with estimations from stock assessments
iniYear <- 2003
# vector of years
dy <- iniYear:fnlYear
# vector of years for valid assessments
vay <- (assessmentYear-2):assessmentYear
# vector of years for stock status projection
vpy <- (fnlYear-2):fnlYear
# options for reading data
options(stringsAsFactors=FALSE)
# number of simulations for mle bootstrap
it <- 500
# number of cores for mle bootstrap parallel
nc <- 3
# quantiles to be computed
qtl <- c(0.025, 0.25, 0.50, 0.75, 0.975)
# to control de seed in mclapply
RNGkind("L'Ecuyer-CMRG")
set.seed(1234)
# to make plots consistent
vp <- dy
vp[c(2,4,6,8,10,12,14)] <- ""
theme_set(theme_bw())
sc <- scale_x_continuous(breaks=dy, labels=as.character(vp))
th <- theme(axis.text.x  = element_text(angle=90, vjust=0.5), panel.grid.minor = element_blank())

#====================================================================
# load & pre-process
#====================================================================

#--------------------------------------------------------------------
# load and pre-process
#--------------------------------------------------------------------

# assessments
gfcm <- read.csv("../data/med/GFCM_SA_2020.csv")
gfcm$Meeting <- "GFCM"
#gfcm$Fref <- gfcm$Fref_point
stecf <- read.csv("../data/med/STECF_CFP_2020.csv")
msa <- rbind(stecf, gfcm)
msa$Fref <- msa$Fref_point

# keep relevant columns only
msa <- msa[,c("Stock", "Area", "Year", "R", "SSB", "F", "Fref", "Blim", "Bref", "asses_year", "Meeting", "Assessment_URL", "Species", "EcoRegion")]

# id assessment source
msa[msa$Meeting!="GFCM","Meeting"] <- "STECF"
names(msa)[names(msa)=="Meeting"] <- "source"

#--------------------------------------------------------------------
# recode and compute indicators
#--------------------------------------------------------------------
msa$stk <- tolower(paste(msa$Stock, msa$Area, sep="_"))
```

```
msa$StockDescription <- paste(msa$Species, "in GSA", gsub("_", ", ",  msa$Area))
msa$Fref <- as.numeric(msa$Fref)
msa <- transform(msa, indF = F/Fref)
msa <- transform(msa, sfFind=!is.na(indF), i1=indF>1, i2=indF<=1)

#-------------------------------------------------------------------
# subset
# (filtering through the sampling frame done during data harvesting)
#-------------------------------------------------------------------
sam <- msa[!is.na(msa$indF) & msa$Year >=iniYear & msa$Year <= fnlYear & msa$asses_year
%in% vay,]

#-------------------------------------------------------------------
# project stock status
# (check fnlYear < assessmentYear-1)
#-------------------------------------------------------------------
sam$projected <- FALSE

# use y-2 for stocks missing in y-1
sy2 <- sam[sam$Year==sort(vpy)[1], "stk"]
sy1 <- sam[sam$Year==sort(vpy)[2], "stk"]
v0 <- sy2[!(sy2 %in% sy1)]
if(length(v0)>0){
    df0 <- subset(sam, Year==sort(vpy)[1] & stk %in% v0)
    df0$Year <- sort(vpy)[2]
    df0$projected <- TRUE
    sam <- rbind(sam, df0)
}

# use y-1 for stocks missing in y
sy <- sam[sam$Year==sort(vpy)[3], "stk"]
v0 <- sy1[!(sy1 %in% sy)]
if(length(v0)>0){
    df0 <- subset(sam, Year==sort(vpy)[2] & stk %in% v0)
    df0$Year <- sort(vpy)[3]
    df0$projected <- TRUE
    sam <- rbind(sam, df0)
}

#===================================================================
# Indicators
#===================================================================
#-------------------------------------------------------------------
# Number of stocks (remove projected years)
#-------------------------------------------------------------------
df0 <- sam[!sam$projected,]
mnStks <- aggregate(stk~Year, df0, length)
names(mnStks) <- c("Year", "N")

# plot
png("figMedI0.png", 1800, 1200, res=300)
ggplot(subset(mnStks, Year!=fnlYear), aes(x=Year, y=N)) +
    geom_line() +
    ylab("No. of stocks") +
    xlab("") +
    ylim(c(0,55)) +
    sc +
    th +
    geom_point(aes(x=fnlYear, y=mnStks$N[length(mnStks$N)]), size=2)
dev.off()

png("figMedI0b.png", 1200, 1600, res=200)
df0 <- sam[!sam$projected,]
ggplot(df0, aes(Year,reorder(stk, desc(stk))))+
    geom_line() +
    geom_point(data=aggregate(list(Year=df0$Year, EcoRegion=df0$EcoRegion),
    by=list(stk=df0$stk), max)) +
    ylab("") +
    xlab("Year") +
    sc +
    th +
    facet_grid(EcoRegion~., switch="y", space="free_y", scales="free_y") +
    theme(strip.placement="outside", strip.background.y=element_blank(),
    panel.spacing.y=unit(0.05, "lines"))
dev.off()

write.csv(dcast(df0, EcoRegion~Year, value.var='stk', margins=TRUE,
fun.aggregate=length), file="tabMedI0.csv", row.names=FALSE)
```

```
#-------------------------------------------------------------------
#  drop final assessment year, redo scales for plotting
#-------------------------------------------------------------------
sam <- sam[sam$Year!=fnlYear,]

vp <- iniYear:I(fnlYear-1)
vp[c(2,4,6,8,10,12,14)] <- ""
sc <- scale_x_continuous(breaks=iniYear:I(fnlYear-1), labels=as.character(vp))

#-------------------------------------------------------------------
# (I7) F/Fmsy model based indicator
#-------------------------------------------------------------------
df0 <- sam
df0$Year <- factor(df0$Year)
yrs <- levels(df0$Year)
nd <- data.frame(Year=factor(yrs))
No <- length(unique(df0$stk))

# model
mfit <- glmer(indF ~ Year + (1|stk), data = df0, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
runDiagsME(mfit, "stk", df0, "diagMedI7.pdf", nc, nd)

# bootstrap
set.seed(1234)
stk <- unique(df0$stk)
mfit.bs <- split(1:it, 1:it)
mfit.bs <- mclapply(mfit.bs, function(x){
    stk <- sample(stk, replace=TRUE)
    df1 <- df0[0,]
    for(i in stk) df1 <- rbind(df1, subset(df0, stk==i))
    fit <- glmer(indF ~ Year + (1|stk), data = df1, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
    v0 <- predict(fit, re.form=~0, type="response", newdata=nd)
    if(length(fit@optinfo$conv$lme4)>0) v0[] <- NA
    v0
}, mc.cores=nc)
# remove failed iters
mfit.bs <- mfit.bs[unlist(lapply(mfit.bs, is.numeric))]

mfitm <- do.call("rbind", mfit.bs)
mfitq <- apply(mfitm, 2, quantile, c(0.025, 0.25, 0.50, 0.75, 0.975), na.rm=TRUE)
mfitq <- cbind(Year=as.numeric(yrs), as.data.frame(t(mfitq)))

# plot
png("figMedI7.png", 1800, 1200, res=300)
ggplot(mfitq, aes(x=Year)) +
    geom_ribbon(aes(ymin = `2.5%`, ymax = `97.5%`), fill="gray", alpha=0.60) +
    geom_ribbon(aes(ymin = `25%`, ymax = `75%`), fill="gray", alpha=0.95) +
    geom_line(aes(y=`50%`)) +
    expand_limits(y=0) +
    geom_point(aes(x=Year[length(Year)], y=`50%`[length(`50%`)]), size=2) +
    geom_hline(yintercept = 1, linetype=2) +
    ylab(expression(F/F[MSY])) +
    xlab("") +
    theme(legend.position = "none") +
    sc +
    th
dev.off()

# table
tb0 <- t(mfitq)[-1,]
colnames(tb0) <- mfitq[,1]
write.csv(tb0, file="tabMedI7.csv")

#-------------------------------------------------------------------
# (I7b) F/Fmsy model regional
#-------------------------------------------------------------------
df0 <- sam
df0$Year <- factor(df0$Year)
yrs <- levels(df0$Year)
nd <- data.frame(Year=factor(yrs))
# remove Eastern Med. where only 2 stocks are available
df0 <- df0[df0$EcoRegion!="Eastern Med.",]

mfitRegional <- lapply(split(df0, df0$EcoRegion), function(x){
    # fit model
```

```
    mfit <- glmer(indF ~ Year + (1|stk), data = x, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
    # no variance with bootstrap due to small number of stocks
    mfit.pred <- predict(mfit, re.form=~0, type="response", newdata=nd)
    # output
    list(mfit=mfit, mfit.pred=mfit.pred)
})

# naming including No of stocks
No <- lapply(split(df0, df0$EcoRegion), function(x) length(unique(x$stk)))
names(mfitRegional) <- paste(names(No), " (", No, ")", sep="")

lst0 <- lapply(mfitRegional, "[[", "mfit.pred")
fIndfr <- data.frame(EcoRegion=rep(names(lst0), lapply(lst0, length)), N=unlist(lst0),
Year=as.numeric(as.character(nd[,1])))

# plot
png("figMedI7b.png", 2400, 1200, res=300)
ggplot(fIndfr, aes(x=Year, y=N)) +
    geom_line() +
    facet_grid(.~EcoRegion) +
    geom_hline(yintercept = 1, linetype=2) +
    ylab(expression(F/F[MSY])) +
    xlab("") +
    sc +
    ylim(0, 3.5) +
    th
dev.off()

# table
write.csv(dcast(fIndfr, EcoRegion~Year, value.var='N'), file="tabMedI7b.csv",
row.names=FALSE)

#--------------------------------------------------------------------
# (I8) SSB indicator
#--------------------------------------------------------------------
# model
# pil_6 has a large impact in the indicator ...
idx <- !is.na(sam$SSB)
df0 <- sam[idx,]
df0$Year <- factor(df0$Year)
yrs <- levels(df0$Year)
nd <- data.frame(Year=factor(yrs))
No <- length(unique(df0$stk))

# model
mfitb <- glmer(SSB ~ factor(Year) + (1|stk), data =  df0, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
runDiagsME(mfitb, "stk", df0, "diagMedI8.pdf", nc, nd)

# bootstrap
set.seed(1234)
stk <- unique(df0$stk)
mfitb.bs <- split(1:it, 1:it)
mfitb.bs <- mclapply(mfitb.bs, function(x){
    stk <- sample(stk, replace=TRUE)
    df1 <- df0[0,]
    for(i in stk) df1 <- rbind(df1, subset(df0, stk==i))
    fit <- glmer(SSB ~ Year + (1|stk), data = df1, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
    v0 <- predict(fit, re.form=~0, type="response", newdata=nd)
    if(length(fit@optinfo$conv$lme4)>0) v0[] <- NA
    v0
}, mc.cores=nc)
# remove failed iters
mfitb.bs <- mfitb.bs[unlist(lapply(mfitb.bs, is.numeric))]

mfitm <- do.call("rbind", mfitb.bs)
mfitm <- exp(log(mfitm)-mean(log(mfitm[,1]), na.rm=TRUE))
mfitq <- apply(mfitm, 2, quantile, c(0.025, 0.25, 0.50, 0.75, 0.975), na.rm=TRUE)
mfitq <- cbind(Year=as.numeric(yrs), as.data.frame(t(mfitq)))

# plot
png("figMedI8.png", 1800, 1200, res=300)
ggplot(mfitq, aes(x=Year)) +
    geom_ribbon(aes(ymin = `2.5%`, ymax = `97.5%`), fill="gray", alpha=0.60) +
    geom_ribbon(aes(ymin = `25%`, ymax = `75%`), fill="gray", alpha=0.95) +
    geom_line(aes(y=`50%`)) +
```

```r
    expand_limits(y=0) +
    geom_point(aes(x=Year[length(Year)], y=`50%`[length(`50%`)]), size=2) +
    geom_hline(yintercept = 1, linetype=2) +
    ylab(expression(B/B[2003])) +
    xlab("") +
    theme(legend.position = "none") +
    sc +
    th
dev.off()

tb0 <- t(mfitq)[-1,]
colnames(tb0) <- mfitq[,1]
write.csv(tb0, file="tabMedI8.csv")

#--------------------------------------------------------------------
# (I8) SSB indicator regional
#--------------------------------------------------------------------
idx <- !is.na(sam$SSB)
df0 <- sam[idx,]
df0$Year <- factor(df0$Year)
yrs <- levels(df0$Year)
nd <- data.frame(Year=factor(yrs))
# remove Eastern Med. where only 2 stocks are available
df0 <- df0[df0$EcoRegion!="Eastern Med.",]

mfitbRegional <- lapply(split(df0, df0$EcoRegion), function(x){
    # fit model
    mfitb <- glmer(SSB ~ factor(Year) + (1|stk), data =  x, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
    # no variance with bootstrap due to small number of stocks
    mfitb.pred <- predict(mfitb, re.form=~0, type="response", newdata=nd)
    # output
    list(mfitb=mfitb, mfitb.pred=mfitb.pred/mfitb.pred[nd==iniYear])
})

# naming including No of stocks
No <- lapply(split(df0, df0$EcoRegion), function(x) length(unique(x$stk)))
names(mfitbRegional) <- paste(names(No), " (", No, ")", sep="")

lst0 <- lapply(mfitbRegional, "[[", "mfitb.pred")
bIndfr <- data.frame(EcoRegion=rep(names(lst0), lapply(lst0, length)), N=unlist(lst0),
Year=as.numeric(as.character(nd[,1])))

# plot
png("figMedI8b.png", 2400, 1200, res=300)
ggplot(bIndfr, aes(x=Year, y=N)) +
    geom_line() +
    facet_grid(.~EcoRegion) +
    geom_hline(yintercept = 1, linetype=2) +
    ylab(expression(B/B[2003])) +
    xlab("") +
    sc +
    th
dev.off()

# table
write.csv(dcast(bIndfr, EcoRegion~Year, value.var='N'), file="tabMedI8b.csv",
row.names=FALSE)

#--------------------------------------------------------------------

write.csv(sam, file="sam.csv")
save.image("RData.med")
```

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